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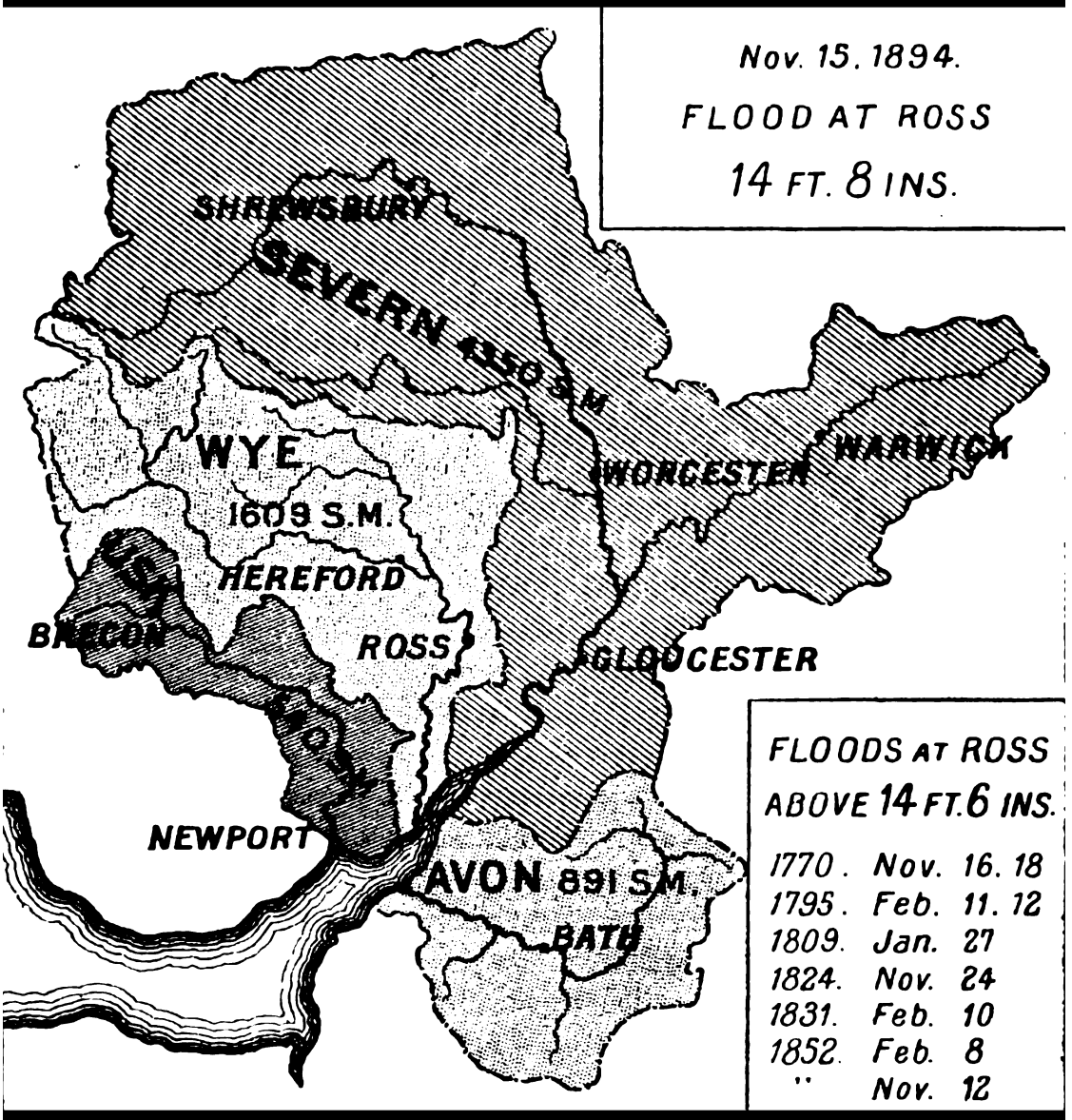

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Royal Meteorological Society.

Offices:—22 GREAT GEORGE STREET, WESTMINSTER, S.W.

SESSION 1894.

ORDINARY MEETINGS at 8 p.m.

January	17	May	16
February	21	June	20
March	21	November	21
April	18	December	19

ANNUAL GENERAL MEETING,

January 16, 1895.

EXHIBITION OF INSTRUMENTS,

April 10th-20th, 1894.

By permission of the Council of the Institution of Civil Engineers, the above Meetings will be held at 25 Great George Street, Westminster, S.W.

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THE GREAT DROUGHT OF 1893,

AND ITS ATTENDANT METEOROLOGICAL PHENOMENA.

By FREDERICK J. BRODIE, F.R.Met.Soc.

[Received October 16th.—Read November 15th, 1893.]

THE drought which prevailed over England and the neighbouring parts of the Continent during the spring and early summer of 1893 was so exceptional, both as regards severity and duration, that little apology is needed for submitting the main facts of the case to the notice of the Society on this, the earliest available, opportunity. The drought itself was followed, after a long showery interval in July, by another spell of fine weather in August and September, so that one was at first tempted to extend the limits of the present inquiry up to Michaelmas. On reflection, however, it seemed quite evident that a wide distinction must be drawn between a drought and a mere deficiency of rain; and as the former characteristic ended with the close of June it was decided to confine this investigation to the weather of the four months commencing with March. July was decidedly unsettled, especially in the extreme south of England, where the rainfall was in many places con-

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siderably in excess of the average, and notwithstanding all the subsequent fine weather there was nothing worthy of the name of a drought either in August or September.

The various elements which go to make up what we call "the weather" are so intimately connected, that it is impossible for one feature to distinguish itself in any abnormal manner without the others being also affected to a greater or less extent. The truth of this was abundantly shown during the period under discussion; for if the absence of rain was phenomenal, the conditions shown by the barometer, the thermometer, and the sunshine recorder were in many ways no less remarkable. Barometric pressure was, as one would naturally expect, greatly in excess of the average; temperature was also high, with a large amount of diurnal range; and the duration of sunshine was in many places the longest on record.

Barometric Pressure.

In endeavouring to trace the origin of the drought one can scarcely fail to be impressed with a sense of the inadequacy of our knowledge respecting the causes which lead even to the greater and more widespread of our climatic variations. We may say, as we do in the present case, that the general character of the weather is governed by the pressure distribution, but here we must stop. Any attempt to go further and to discover what it is that leads to the formation of the cyclones and the anticyclones lands us at once in a debatable region from which the mists of theory have not yet rolled away. For the present it is sufficient to state that the great drought of 1893 was due, so far as can be seen, to the almost constant prevalence of large anticyclonic systems. During the four months under discussion no fewer than eight such areas were observed over a large portion of the United Kingdom, their aggregate duration extending over 77 days out of the 122 comprised within the four months' record. In addition to these cases there were several other instances in which the southern portions of the Kingdom only were influenced by anticyclones which spread over from the Continent. At times the distribution of pressure over our Islands became cyclonic, the depressions advancing in most cases from the northward, but even when this change occurred the tendency for fine dry weather was so pronounced that the showers experienced were very local, and in some places exceedingly slight. On one or two occasions the presence of a definite depression over our southern counties was altogether unattended by rain, or indeed by any unsettled appearance of the sky. The leading characteristics of the several anticyclones are shown in the following notes, together with a few facts respecting the intervals of cyclonic weather which occurred between each high pressure system.

No. I. March 5-10. An anticyclone of moderate size spread over our Islands from the westward on March 5th. The central portion of the system remained off our south-west coasts until the 10th, when the entire area moved away in a south-easterly direction to the Mediterranean. During its prevalence the wind over our Islands varied between West and North-west; temperature was high generally, but the nights cold; the weather was very dry in all but our extreme northern and north-western districts.

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MARCH 11-16. Some depressions hitherto observed in the far north now spread over us. Westerly and South-westerly winds therefore set in generally, with lower temperatures and with showers in all districts. Snow or sleet was fairly general on the 16th and 17th.

No. II. MARCH 18 29. This system advanced over our Islands from the Atlantic on March 18th, and was at first of moderate size, but gradually extended in all directions until it finally embraced nearly the whole of Europe. The central area lay at first directly over the United Kingdom, whence it moved eastwards to the Netherlands and north-eastwards to Scandinavia, the latter country being reached on the 24th. Between the 27th and 29th the system moved southwards to central Europe, where it partially dispersed. The winds over the United Kingdom were at first very variable, then Easterly; temperature was high in the daytime, but very low at night; the weather was fine and dry generally.

MARCH 30-APRIL 1. Shallow depressions in the far north spread southwards, and Westerly and South-westerly winds again set in, with showers in all but our eastern and southern districts, where the weather remained exceedingly dry.

No. III. APRIL 1-14. On April 1st two anticyclonic areas appeared,—one over Russia and the other off our south-west coasts. The systems afterwards increased in size until they formed one large anticyclone, which spread over the whole of Europe by April 5th. After the 9th depressions began to advance over the north of Scandinavia from the westward, and the anticyclone, which had already undergone several modifications in form, moved slowly southwards. By the 15th its influence had practically disappeared from north-western Europe. The winds over our Islands, which were at first variable, finally became Easterly. Temperature exhibited great fluctuations, but was mostly above the average, sharp night frosts being experienced, however, in all the inland districts. The weather was fine and bright excepting in the extreme north, and even there the rainfall was below the normal.

APRIL 15-16. Shallow depressions appeared first in the north and afterwards in the west, and showers fell in all the more western and northern parts of the Kingdom.

No. IV. APRIL 17-28. An anticyclone formed over the North Sea on April 17th, and gradually spread over a considerable portion of the Continent. After the 24th depressions appeared over France and Spain, and the southern portion of the high pressure system gave way. The weather over our Islands remained, however, under its influence until the 28th, when the anticyclone apparently moved away to the Atlantic. During its prevalence the winds, though rather variable, were mostly from some Easterly quarter. Temperature was very high, especially on the 19th and 20th, when the thermometer rose to above 80° in many parts of England. The weather was very fine over England and Ireland, but gradually became unsettled in Scotland.

APRIL 29-MAY 2. A depression first spread south-eastwards from our northern coasts across the North Sea, and North-westerly winds with showery weather set in generally. On May 2nd another disturbance passed northwards along the Irish and Scotch coasts. Decided falls of rain were experienced in the western and northern parts of the United Kingdom, but in the south-eastern districts the rainfall was slight and very local.

No. V. MAY 3-13. On May 3rd the barometer rose generally, and a large anticyclone was quickly formed over the whole of Europe, its central area being located for the most part over the northern countries. After the 10th the system became reduced in size, owing to the appearance of depressions in the far northern and also in the southern portions of Europe. On the 14th the remaining portion of the anticyclone, which had by this time settled down over the more central countries, gradually dispersed. During its prevalence the winds in our Islands were mostly Easterly; temperature was high, though less so than it had been with anticyclone No. IV.; and the weather was fine and dry in all but the extreme northern and north-western districts.

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A rather long period of unsettled weather now ensued, during which a series of depressions travelled northward along our western coasts, their secondaries in many instances advancing directly over the United Kingdom. Southerly (South-east to South-west) winds prevailed generally, temperature remained high with warmer nights than had been experienced for a long time past; and rainfall, though varying greatly in different localities, was fairly abundant in all but the eastern and southern parts of the Kingdom.

No. VI. MAY 25-JUNE 1. The sixth anticyclone advanced from the Atlantic on May 25th, and soon spread eastwards over the entire Kingdom, lasting till June 1st. The central portion remained for the most part off our western coasts, and the prevailing winds were, therefore, North-westerly or Northerly. Temperature fell generally, but did not sink much below the normal; the weather was rather showery, with thunderstorms in many places.

On June 2nd and 3rd a depression passed along our western coasts occasioning further showers in most parts of the Kingdom. In the east and south of England, however, the rainfall was slight and very local.

No. VII. JUNE 4-12. This system spread over our Islands from the southward on June 4th, and gradually increased in size until it covered the greater part of Europe. After the 10th, however, its area became greatly diminished, and between the 12th and 15th it almost entirely dispersed over Scandinavia. The winds, although rather variable in the north of our Islands, were mostly from the Eastward; temperature was high, and, with the exception of one or two local falls of rain of considerable amount (due to thunderstorms), the weather was again fine and dry.

On the 13th and 14th a complex area of low pressure spread over us from the southward, but with the exception of a few local thunderstorms the weather was not materially affected.

No. VIII. JUNE 15-19. A general rise of the barometer took place on June 15th and 16th, and a large anticyclone was soon developed over our Islands and the greater part of the Continent. After the 17th, however, when depressions spread over northern and eastern Europe from the northward, the system became reduced in size and gradually passed away over the Atlantic. During its prevalence in our neighbourhood light variable winds were general; temperature was exceedingly high, maxima varying between 85° and 90° being registered in many parts of Great Britain. The weather was very fine until the 19th, when smart thunderstorms occurred in the south and south-east of England.

The remainder of June was unsettled and showery, with a temperature differing but little from the normal. On the 22nd and 23rd a well marked depression advanced in a south-south-easterly direction over the northern and eastern parts of Great Britain and occasioned cool Northerly and North-westerly winds in all districts, while from the 26th to 29th the weather was influenced by some rather large disturbances which travelled across the more northern parts of our Islands from the Atlantic. Quite at the close of the month another large anticyclone was again developed over western Europe and remained under observation during the early days of July.

One of the most important features in connection with the anticyclones whose career we have briefly sketched was the remarkable manner in which they developed from areas of moderate size into huge systems which frequently embraced the whole of Europe. The source whence the feeding power was derived suggests questions of the highest interest, for it is quite certain that if the causes which lead to the formation and movements of anticyclones were clearly understood, we should have a very important key to the whole chain of events governing our weather changes. The effect of so much anticyclonic weather on the instrumental records is shown in Table

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I., which gives for 30 stations, situated in various parts of the British Islands, the mean barometric pressure for each of the four months, and also for the period as a whole, with its difference from the average for the 20 years 1871-90. The values are compiled from observations made at 8 a.m. only, but experience shows that the mean pressure at that hour differs very slightly from that derived from 24 hourly readings. It will be seen that there was in each month an excess of pressure in all parts of the Kingdom.

TABLE I.—MEAN BAROMETRICAL PRESSURE AT 8 A.M., MARCH TO JUNE, 1893.

Stations.	March.		April.		May.		June.		The Entire Period.	
	Mean Pressure.	Diff. from Average.	Mean Pressure.	Diff. from Average.	Mean Pressure.	Diff. from Average.	Mean Pressure.	Diff. from Average.	Mean Pressure.	Diff. from Average.
	Ins.	In.	Ins.	In.	Ins.	In.	Ins.	In.	Ins.	In.
SCOTLAND, N.		+		+		+		+		+
Sumburgh Head	29·776	·025	30·083	·243	30·014	·135	29·942	·059	29·954	·116
Wick	29·845	·052	30·111	·263	30·010	·109	29·972	·074	29·985	·125
Stornoway	29·869	·091	30·109	·285	29·972	·086	29·952	·076	29·976	·135
SCOTLAND, E.										
Nairn	29·898	·088	30·128	·280	30·001	·093	29·960	·056	29·997	·129
Aberdeen	29·937	·112	30·174	·316	30·045	·127	29·980	·064	30·034	·155
Leith	29·984	·131	30·179	·316	30·036	·104	29·972	·042	30·043	·148
ENGLAND, N.E.										
Shields	30·015	·135	30·195	·329	30·057	·114	29·983	·035	30·063	·154
York	30·066	·158	30·207	·332	30·074	·112	30·007	·038	30·089	·160
Spurn Head	30·050	·154	30·187	·324	30·059	·103	29·987	·023	30·071	·151
ENGLAND, E.										
Yarmouth	30·089	·169	30·180	·308	30·063	·096	30·003	·026	30·084	·150
Cambridge	30·136	·195	30·200	·320	30·082	·106	30·019	·034	30·109	·163
MIDLAND COUNTIES.										
Loughborough	30·119	·187	30·207	·328	30·081	·108	30·023	·043	30·108	·167
Oxford	30·149	·198	30·186	·302	30·079	·098	30·021	·035	30·109	·158
ENGLAND, S.										
London	30·148	·198	30·179	·301	30·079	·098	30·028	·036	30·109	·159
North Foreland	30·127	·197	30·153	·283	30·059	·089	29·997	·017	30·084	·146
Dungeness	30·131	·193	30·135	·271	30·054	·084	29·999	·017	30·080	·141
Hurst Castle	30·159	·205	30·148	·277	30·071	·089	30·023	·025	30·100	·149
SCOTLAND, W.										
Ardrossan	30·001	·136	30·160	·303	30·030	·095	29·972	·040	30·041	·144
ENGLAND, N.W.										
Liverpool	30·093	·182	30·187	·320	30·065	·104	30·002	·036	30·087	·161
Holyhead	30·080	·173	30·161	·304	30·049	·093	29·999	·033	30·072	·150
ENGLAND, S.W.										
Pembroke	30·121	·192	30·148	·296	30·047	·086	30·016	·042	30·083	·154
Prawle Point	30·152	·187	30·128	·252	30·065	·073	30·019	·012	30·091	·131
IRELAND, N.										
Malin Head	29·971	·106	30·143	·303	29·998	·073	29·981	·051	30·023	·133
Donaghadee	30·053	·171	30·182	·323	30·050	·103	29·998	·052	30·071	·162
Belmullet	30·032	·157	30·166	·331	30·011	·086	30·003	·068	30·053	·160
IRELAND, S.										
Parsonstown	30·075	·150	30·167	·303	30·029	·071	30·013	·041	30·071	·141
Valencia	30·106	·181	30·153	·299	30·022	·059	30·031	·056	30·078	·149
Roche's Point	30·109	·182	30·164	·313	30·038	·079	30·028	·055	30·085	·157
CHANNEL ISLANDS.										
Scilly	30·124	·177	30·096	·240	30·025	·051	30·014	·018	30·065	·122
Jersey	30·174	·213	30·107	·235	30·072	·083	30·029	·019	30·096	·138

In March the difference from the normal was slight in the north of Scotland, but considerable elsewhere, the greatest divergence being shown in the extreme

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south of England, where the values were about 0·2 in. above the average. At Kew there have been only two years since 1870 (1874 and 1875) which had a higher mean pressure in March.

In April the excess of pressure was very much greater than in March, the difference from the normal amounting to more than three-tenths of an inch at a considerable number of the stations. At Kew the mean pressure in this month was the highest on record for April, though not much higher than that in 1870. The unusual height of the barometer was all the more remarkable when we remember that for some hitherto unexplained reason April has a lower mean pressure than any other month in the year.

In May the excess of pressure was very much less than in April and appreciably less than in March, the districts with the largest excess being the northern and eastern parts of Great Britain, where the values were more than a tenth of an inch above the average.

In June the excess was less marked even than in May, being less than five hundredths of an inch at most of the English stations, and less than two hundredths in the extreme south.

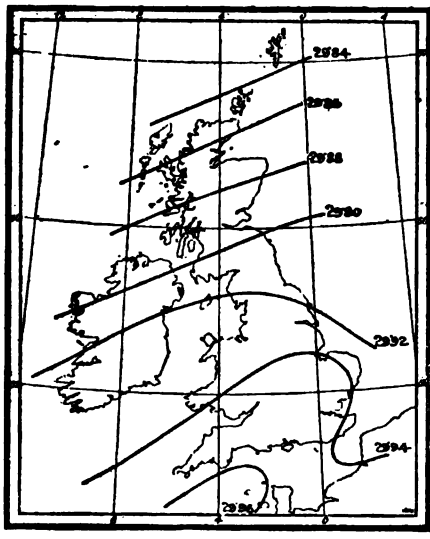

FIG. 1.
Average Distribution of Pressure, March to June, for the 20 years, 1871–90.

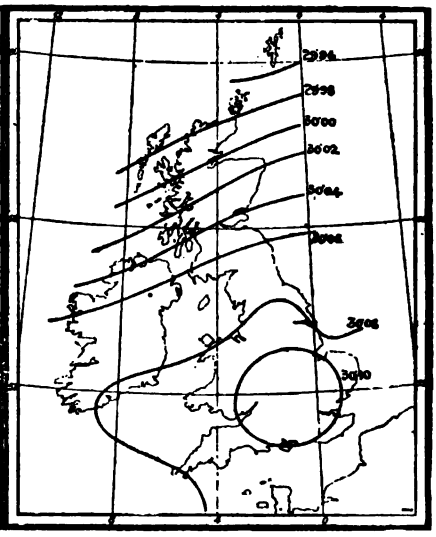

FIG. 2.
Distribution of Pressure, March to June, 1893.

Taking the period of four months as a whole, the mean values showed a large excess in all parts of the Kingdom, the difference from the normal being greatest (0·16 in. or more) over the central parts of England, and least (0·12 in. or less) in the extreme north of Scotland and also in the Scilly Islands. At Kew the mean for the entire period was higher than any observed during a similar time of the year since the year 1870. The general result for the four months is shown very clearly in Figs. 1 and 2, the isobars in which are drawn for every two hundredths of an inch. Fig. 1 represents the average

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distribution based on values extending over the 20 years 1871-90, and Fig. 2 the distribution of mean pressure in 1893. With regard to the actual values, it will be seen that the line of highest pressure in the map of averages appears only as the line of lowest pressure in the chart for 1893, every isobar in the latter being of a far higher value. The general distribution of pressure shown by the two maps is also very different. In the average map there is a moderate gradient for South-westerly winds over the entire Kingdom, the tendency being cyclonic in the northern but anticyclonic in the southern districts. In the map for 1893 the South-westerly gradient is confined to the more northern parts of the Kingdom, where it is steeper than usual. Over England the distribution is decidedly anticyclonic.

Temperature.

The mean temperature was above the average for the 20 years 1871-90 in each of the four months, and in almost all parts of the Kingdom, the excess being upon the whole greatest in April and May, rather less in March, and considerably less in June. Taking the period as a whole, the mean temperature over England was about 4° above the average, but considerable local variations were observed, the difference from the normal being in some cases very little more than 2°, and in other places as much as 5°. To obtain a clearer conception of the abnormal temperatures of the period it is, however, necessary to analyse the records a little more closely, the mean values alone giving a very inadequate idea of the influence of the strong anticyclonic tendency which prevailed throughout the four months. In the winter time an anticyclone is accompanied, as most persons are aware, by cold weather, and in the summer time by warmth. In the spring and autumn the anticyclone brings us a combination of these two qualities, and so in the period under discussion we find that while the day temperatures were mostly very high, the nights were cold, with frequent sharp frosts in the inland districts. The effect of these conflicting influences is shown very clearly in Table II., where the means of the maximum and minimum readings taken at a number of stations situated in various parts of England are compared with the average for the 20 years 1871-90.

A careful examination of the table shows that the diurnal range was not very much in excess of the average in May or June, but that it was decidedly large in March, and still larger in April, when the anticyclonic conditions were most pronounced. The difference existing between the range of temperature in the inland districts as compared with that on the coast has seldom been more forcibly illustrated than in the period under review. Taking the month of April, for example, we find that at Cambridge the mean of the daily maxima was more than 11° in excess of the average, while the mean of the minima was 0°·7 below it. At Yarmouth, in the same district but on the coast, the maximum readings were only a degree above the average, while the minimum readings were also above the normal. The maximum readings at Cambridge were in fact as much as 17° higher than those at Yarmouth, while the minima at the inland station were more than 4° lower than those on the coast. The

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TABLE II.—MEAN TEMPERATURE AND MEAN MAXIMUM AND MINIMUM TEMPERATURES EXPERIENCED OVER VARIOUS PARTS OF ENGLAND, MARCH TO JUNE 1893, WITH THE MEAN DAILY RANGE, AND WITH DIFFERENCES FROM THE AVERAGE.

Stations.	March.								April.								May.			
	Mean Temperature.		Daily Maxima.		Daily Minima.		Mean Daily Range.		Mean Temperature.		Daily Maxima.		Daily Minima.		Mean Daily Range.		Mean Temperature.		Daily Maxima.	
	Mean.	Diff. from Average.	Mean.	Diff. from Average.	Mean.	Diff. from Average.	Mean.	Diff. from Average.	Mean.	Diff. from Average.	Mean.	Diff. from Average.	Mean.	Diff. from Average.	Mean.	Diff. from Average.	Mean.	Diff. from Average.	Mean.	Diff. from Average.
ENGLAND, N.E.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Durham	44·4	+4·3	53·8	+7·1	35·0	+1·6	18·8	+5·5	46·8	+2·9	57·0	+ 5·4	36·5	+0·3	20·5	+ 5·1	52·8	+4·1	62·2	+5·1
Scarborough ..	44·4	+3·4	51·3	+5·3	37·4	+1·4	13·9	+3·9	45·2	+0·6	51·5	+ 2·0	38·8	—0·8	12·7	+ 2·8	52·0	+2·5	58·1	+2·8
York	45·1	+4·0	55·7	+7·6	34·5	+0·5	21·2	+7·1	49·6	+4·0	61·6	+ 8·1	37·6	—0·1	24·0	+ 8·2	54·8	+3·9	64·5	+4·9
ENGLAND, E.																				
Hillington.....	45·0	+3·6	56·0	+7·0	33·9	+0·2	22·1	+6·8	49·1	+3·2	60·8	+ 6·5	37·4	0·0	23·4	+ 6·5	54·6	+3·4	64·6	+3·9
Yarmouth.....	43·8	+3·7	49·7	+4·5	37·8	+2·9	11·9	+1·6	45·7	+1·2	50·3	+ 1·2	41·0	+1·1	9·3	+ 0·1	52·5	+2·3	57·6	+2·2
Cambridge	46·6	+5·0	59·5	+9·3	33·6	+0·6	25·9	+8·7	51·9	+5·3	67·2	+11·4	36·6	—0·7	30·6	+12·1	56·7	+4·7	68·8	+6·8
MID. COUNTIES.																				
Loughborough ..	45·8	+3·9	58·2	+8·7	33·4	—0·8	24·8	+9·5	50·6	+4·0	64·5	+ 9·4	36·7	—1·4	27·8	+10·8	55·5	+3·3	66·6	+4·9
Oxford	6·0	+4·0	57·1	+8·1	34·9	0·0	22·2	+8·1	51·8	+5·3	64·4	+10·4	39·1	+0·2	25·3	+10·2	56·6	+4·6	67·1	+6·5
ENGLAND, S.																				
London	46·3	+3·6	56·7	+6·7	35·9	+0·5	20·8	+6·2	52·8	+4·9	64·4	+ 8·4	41·2	+1·5	23·2	+ 6·9	57·8	+4·4	67·8	+5·5
Strathfield T. ..	45·5	+3·4	57·3	+7·1	33·6	—0·4	23·7	+7·5	51·5	+4·7	66·7	+10·7	36·2	—1·4	30·5	+12·1	56·2	+4·0	69·0	+6·4
Hastings (St. Leonard's)	46·6	+3·8	53·2	+4·7	39·9	+2·9	13·3	+1·8	52·1	+4·7	60·6	+ 6·9	43·6	+2·6	17·0	+ 4·3	55·4	+2·9	62·7	+3·0
ENGLAND, N.W.																				
Stonyhurst	44·0	+3·4	50·8	+3·9	37·1	+2·8	13·7	+1·1	49·0	+3·7	58·2	+ 5·3	39·7	+2·1	18·5	+ 3·2	53·4	+2·9	60·8	+2·0
Manchester	46·1	+5·1	54·3	+6·9	37·9	+3·4	16·4	+3·5	50·9	+5·4	61·0	+ 7·9	40·7	+2·9	20·3	+ 5·0	54·6	+4·3	62·7	+4·1
Holyhead	46·9	+3·8	52·4	+5·2	41·4	+2·5	11·0	+2·7	50·6	+3·9	56·6	+ 5·2	44·5	+2·5	12·1	+ 2·7	54·9	+3·7	60·7	+4·5
ENGLAND, S.W.																				
Pembroke	46·5	+3·6	50·4	+3·8	42·5	+3·4	7·9	+0·4	51·5	+5·3	57·4	+ 7·0	45·5	+3·6	11·9	+ 3·4	54·6	+4·1	59·6	+4·6
Cullompton	46·0	+3·4	56·2	+6·4	35·8	+0·5	20·4	+5·9	52·5	+6·1	65·2	+10·8	39·7	+1·4	25·5	+ 9·4	56·3	+4·9	66·3	+5·8
Plymouth	47·6	+3·4	54·5	+4·3	40·7	+2·6	13·8	+1·7	53·3	+4·9	61·1	+ 6·2	45·5	+3·7	15·6	+ 2·5	56·4	+2·8	62·9	+2·2

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TABLE II.—MEAN TEMPERATURE AND MEAN MAXIMUM AND MINIMUM TEMPERATURES EXPERIENCED OVER VARIOUS PARTS OF ENGLAND, MARCH TO JUNE 1893, WITH THE MEAN DAILY RANGE, AND WITH DIFFERENCES FROM THE AVERAGE—*Continued.*

Stations.	May.				June.								The Entire Period.							
	Daily Minima.		Mean Daily Range.		Mean Temperature.		Daily Maxima.		Daily Minima.		Mean Daily Range.		Mean Temperature.		Daily Maxima.		Daily Minima.		Mean Daily Range.	
	Mean.	Diff. from Average.	Mean.	Diff. from Average.	Mean.	Diff. from Average.	Mean	Diff. from Average.	Mean.	Diff. from Average.	Mean.	Diff. from Average.	Mean.	Diff. from Average.	Mean.	Diff. from Average.	Mean.	Diff. from Average.	Mean.	Diff. from Average.
ENGLAND, N.E.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Durham.....	43·4	+3·1	18·8	+2·0	58·1	+2·3	67·1	+2·1	49·0	+2·5	18·1	−0·4	50·5	+3·4	60·0	+4·9	41·0	+1·9	19·0	+3·0
Scarborough....	45·8	+2·2	12·3	+0·6	56·9	+1·3	63·0	+1·6	50·7	+0·9	12·3	+0·7	49·6	+1·9	56·0	+2·9	43·2	+0·9	12·8	+2·0
York	45·1	+2·9	19·4	+2·0	59·3	+2·0	69·0	+2·9	49·5	+1·1	19·5	+1·8	52·2	+3·5	62·7	+5·9	41·7	+1·1	21·0	+4·8
ENGLAND, E.																				
Hillington.....	44·5	+2·9	20·1	+1·0	59·3	+1·6	69·9	+2·2	48·7	+1·1	21·2	+1·1	52·0	+3·0	62·8	+4·9	41·1	+1·0	21·7	+3·9
Yarmouth.....	47·4	+2·5	10·2	−0·3	57·0	+0·4	62·3	+0·3	51·6	+0·5	10·7	−0·2	49·8	+2·0	55·0	+2·1	44·5	+1·8	10·5	+0·3
Cambridge	44·6	+2·6	24·2	+4·2	61·3	+2·7	73·9	+5·3	48·7	+0·2	25·2	+5·1	54·2	+4·5	67·4	+8·2	40·9	+0·7	26·5	+7·5
MID. COUNTIES.																				
Loughborough..	44·4	+1·8	22·2	+3·1	60·2	+1·4	71·7	+3·1	48·6	−0·4	23·1	+3·5	53·1	+3·2	65·3	+6·6	40·8	−0·2	24·5	+6·8
Oxford	46·0	+2·6	21·1	+3·9	61·0	+2·8	71·5	+4·6	50·5	+1·0	21·0	+3·6	53·8	+4·1	65·0	+7·4	42·6	+0·9	22·4	+6·5
ENGLAND, S.																				
London	47·7	+3·3	20·1	+2·2	62·1	+2·2	72·7	+3·6	51·4	+0·8	21·3	+2·8	54·8	+3·8	65·4	+6·0	44·1	+1·6	21·3	+4·4
Strathfield T. ..	43·4	+1·7	25·6	+4·7	60·5	+2·0	73·2	+4·4	47·8	−0·3	25·4	+4·7	53·5	+3·6	66·6	+7·2	40·3	−0·1	26·3	+7·3
Hastings (St. Leonard's)	48·0	+2·7	14·7	+0·3	60·0	+1·7	67·5	+2·2	52·4	+1·1	15·1	+1·1	53·5	+3·2	61·0	+4·2	46·0	+2·3	15·0	+1·9
ENGLAND, N.W.																				
Stonyhurst	45·9	+3·8	14·9	−1·8	58·7	+2·2	66·9	+2·0	50·4	+2·4	16·5	−0·4	51·3	+3·1	59·2	+3·3	43·3	+2·8	15·9	+0·5
Manchester	46·4	+4·5	16·3	−0·4	59·3	+2·7	68·5	+3·4	50·1	+2·1	18·4	+1·3	52·7	+4·3	61·6	+5·5	43·8	+3·2	17·8	+2·3
Holyhead	49·1	+2·9	11·6	+1·6	58·8	+2·2	65·1	+3·5	52·4	+0·9	12·7	+2·6	52·8	+3·4	58·7	+4·6	46·9	+2·2	11·8	+2·4
ENGLAND, S.W.																				
Pembroke	49·6	+3·7	10·0	+0·9	59·3	+3·4	64·5	+4·2	54·0	+2·5	10·5	+1·7	53·0	+4·1	58·0	+4·9	47·9	+3·3	10·1	+1·6
Cullompton	46·3	+4·1	20·0	+1·7	60·5	+2·8	72·1	+5·2	48·8	+0·4	23·3	+4·8	53·9	+4·4	65·0	+7·1	42·7	+1·6	22·3	+5·5
Plymouth	49·8	+3·3	13·1	+1·1	60·7	+1·4	68·5	+2·4	52·8	+0·4	15·7	+2·0	54·5	+3·1	61·8	+3·8	47·2	+2·5	14·6	+1·3

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mean daily range at Cambridge and also at Strathfield Turgiss for the month of April was over 30°, or more than 12° in excess of the average. At Yarmouth, however, the daily range was normal, and at the other coast stations it was not much above the average. The same feature is shown, though in a less marked degree, throughout the whole four months, the mean daily range for the entire period being exceedingly large—22° to 27°—in the midland counties and at most of the inland stations in the east and south of England, but comparatively small—10° to 15°—in nearly all localities in proximity to the sea.

Bright Sunshine.

The main facts relating to the sunshine of the period are given in Table III., which has been compiled from the records made at 48 stations situated in various parts of the United Kingdom. The table gives for each month and for the entire period, firstly, the number of hours of bright sunshine, with the difference from the average for the 10 years 1881-90, in all places for which such an average exists; secondly, the percentage of the possible duration; thirdly, the mean amount of sunshine per day; and fourthly, the number of days on which bright sunshine was entirely absent.

The figures show that in March the amount recorded was in excess of the average at all stations excepting those in the west of Ireland and the north of Scotland, the excess being large in almost all the English districts, and greatest of all in the midland counties. The percentage of the possible duration was above 50 at nearly all the eastern, central, and southern stations, while in the Channel Islands it exceeded 60. The number of sunless days was smallest in the midland counties, where three stations out of five reported only one such occasion.

In April the total number of hours recorded was above the average in all districts, the excess being somewhat small in Ireland and Scotland, but very large over England, and especially so in the eastern, midland, and southern districts. In the regions last mentioned the percentage of the possible amount was considerably over 60, and in the Channel Islands it ranged between 71 and 72, while at Westbourne it rose to 74. At the Channel stations generally the mean daily amount of sunshine in April exceeded 9 hours, the highest proportion of all being at Westbourne, where the sun shone brightly for an average of more than 10 hours per day. Less than two sunless days were recorded over a considerable portion of England, and at the Channel stations there were none at all.

May was decidedly less sunny than either March or April, the total number of hours recorded being below the average in Ireland, Scotland, and the north of England, and not very much above the normal even in the southern parts of the Kingdom. Over England generally the percentage of the possible duration was below 50, and in the more northern districts it was mostly below 40. At some of the Channel stations, however, there was more than half the possible amount, while at Guernsey and Jersey the percentage values were respectively 65 and 62. In the south-west of England sunless

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days were rather more frequent than in April, but in our eastern and southern counties and in the Channel Islands there were no such occasions. Three out of the six Irish stations also reported an entire absence of sunless days,—a somewhat remarkable fact when we remember that the total duration for the month was considerably less than the normal.

June was far more sunny than May, the only stations showing a deficiency being Aberdeen and Parsonstown. In the eastern and midland counties of England the difference from the average was not very large, but in the southern counties the excess was greater, while in the south-western districts and the Channel Islands it was very considerable. The percentage of the possible duration was again below 40 at several of the northern English stations, and below 50 in the eastern and midland counties. In the southern districts, however, it exceeded 50, and on the coasts of Devon and Cornwall it exceeded 60, while at Jersey the sunshine again amounted, as in April, to 72 per cent. of the possible. The mean amount of sunshine per day was as much as 10·5 hours at Falmouth and 11·0 hours at Newquay and Guernsey, while at Jersey it was no less than 11·5 hours, the total amount registered during the month at the last mentioned station being the largest ever observed in any part of the Kingdom.

The record for the entire four months is given in the last five columns of the table and also in a more graphic form in the map, Fig. 8 (p. 14), which shows the relative prevalence of sunshine over different parts of the country. The figures on the map give for certain selected stations, firstly, in italic type, the number of sunless days, and secondly, in ordinary type, the mean daily amount recorded during the whole four months.

The stations in Ireland and Scotland are not sufficiently numerous to enable any very correct conclusions to be drawn, but so far as the records go they show that the percentage of the possible duration was below 40 in most parts of those countries, the lowest value of all being 22 per cent. at Fort Augustus. Over the northern parts of England, and also in the south and east of Ireland, there was, generally speaking, between 40 and 50 per cent. of the possible amount, but at Manchester, where the effects of smoke probably came into operation, the percentage value was as low as 38. In nearly all the more southern parts of England and Wales the percentage was above 50, the only exceptions being Greenwich and Margate; at the former station there was only 44 per cent., and at the latter 48 per cent. On the south and south-west coasts of England the values ranged between 55 and 60, the latter figure being reached at Falmouth. This very high percentage was, however, considerably exceeded in the Channel Islands, the value both at Guernsey and Jersey being no less than 67 per cent.

To grasp the full significance of these facts it must be borne in mind that if the sun shines during a whole month for more than half the possible time the record is considered a remarkably good one, a percentage of 60 or more for such a period being very unusual in these Islands. During the period under discussion we have at a large number of stations on our south and south-west coasts a percentage very little under 60 for a period extending

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TABLE III.—Duration of Bright Sunshine in various parts of the United Kingdom, March to June 1893.

Stations.	March.					April.					May.					June.					The Entire Period.				
	Total No. of Hours Recorded.	Diff. from Average.	Percentage of Possible Duration.	Mean Daily Amount.	No. of Sunless Days.	Total No. of Hours Recorded.	Diff. from Average.	Percentage of Possible Duration.	Mean Daily Amount.	No. of Sunless Days.	Total No. of Hours Recorded.	Diff. from Average.	Percentage of Possible Duration.	Mean Daily Amount.	No. of Sunless Days.	Total No. of Hours Recorded.	Diff. from Average.	Percentage of Possible Duration.	Mean Daily Amount.	No. of Sunless Days.	Total No. of Hours Recorded.	Diff. from Average.	Percentage of Possible Duration.	Mean Daily Amount.	No. of Sunless Days.
Scotland, N.	hrs.	hrs.	%	hrs.		hrs.	hrs.	%	hrs.		hrs.	hrs.	%	hrs.		hrs.	hrs.	%	hrs.		hrs.	hrs.	%	hrs.	
Stornoway	92	— 7	25	3·0	3	163	+ 11	38	5·4	1	138	—48	27	4·5	3	180	+ 1	34	6·0	4	573	— 43	31	4·7	11
Fort Augustus	63	?	17	2·0	13	124	?	29	4·1	7	85	?	17	2·7	9	135	?	26	4·5	7	407	?	22	3·3	36
Fort William	107	?	30	3·5	6	174	?	41	5·8	3	128	?	25	4·1	2	174	?	33	5·8	5	583	?	32	4·8	16
Scotland, E.																									
Aberdeen	179	+67	49	5·8	4	164	+ 21	39	5·5	4	153	—40	30	4·9	6	173	—22	33	5·8	5	669	+ 26	37	5·5	19
*Braemar	168	?	46	5·4	2	173	?	41	5·8	6	160	?	32	5·2	4	186	?	35	6·2	7	687	?	38	5·6	19
Edinburgh	137	?	38	4·4	4	165	?	39	5·5	5	138	?	28	4·5	3	185	?	36	6·2	5	625	?	35	5·1	17
Marchmont	160	?	44	5·2	3	188	?	45	6·3	4	160	?	32	5·2	2	222	?	43	7·4	4	730	?	41	6·0	13
England, N.E.																									
Durham	166	+62	46	5·4	3	173	+ 60	41	5·8	7	160	—17	32	5·2	5	194	+32	38	6·5	3	693	+137	39	5·7	18
Oswaldkirk	180	?	49	5·8	3	227	?	54	7·6	1	175	?	36	5·6	5	170	?	34	5·7	1	752	?	42	6·2	10
York	153	+54	42	4·9	4	240	+111	57	8·0	2	198	+11	40	6·4	4	197	+28	39	6·6	1	788	+204	44	6·5	11
England, E.																									
Hillington	169	+62	46	5·5	3	244	+ 98	59	8·1	1	221	+10	46	7·1	0	230	+37	46	7·7	2	864	+207	49	7·1	6
Geldeston	193	+69	53	6·2	2	234	+ 71	57	7·8	1	236	+ 7	49	7·6	0	244	+32	50	8·1	0	907	+179	52	7·4	3
Cambridge	208	+90	57	6·7	2	266	+118	64	8·9	1	221	+21	46	7·1	0	238	+46	48	7·9	1	933	+275	53	7·6	4
Rothamsted	199	?	55	6·4	1	271	?	66	9·0	1	217	?	45	7·0	0	225	?	46	7·5	1	912	?	52	7·5	3
Midland Counties.																									
Worksop	164	+66	45	5·3	2	218	+ 95	52	7·3	2	182	+ 7	37	5·9	2	178	+21	36	5·9	2	742	+189	42	6·1	8
Thurcaston	183	+96	50	5·9	2	257	+142	62	8·6	1	209	+33	43	7·0	1	208	+49	42	6·9	1	857	+320	49	7·0	5
Churchstoke	198	+93	54	6·4	1	221	+ 85	53	7·4	2	208	+22	43	6·7	2	227	+49	46	7·6	0	854	+249	48	7·0	5
Cirencester	182	+72	50	5·9	1	258	+116	63	8·6	2	226	+29	47	7·3	1	214	+27	43	7·1	0	880	+244	50	7·2	4
Oxford	201	+89	55	6·5	1	256	+115	62	8·5	2	213	+21	44	6·9	1	217	+30	44	7·2	0	887	+255	51	7·3	4
England, S.																									
Greenwich	155	+63	42	5·0	3	231	+103	56	7·7	1	187	+ 1	39	6·0	1	198	+27	40	6·6	2	771	+194	44	6·3	7
Margate	196	?	54	6·3	2	209	?	51	7·0	3	225	?	47	7·3	0	209	?	43	7·0	0	839	?	48	6·9	5
Hastings (St. Leonard's)	208	+72	57	6·7	4	282	+115	69	9·4	0	241	+ 4	50	7·8	0	281	+62	57	9·4	1	1012	+253	58	8·3	5
Eastbourne	213	?	58	6·9	4	274	?	67	9·1	0	218	?	46	7·0	0	263	?	54	8·8	1	968	?	56	7·9	5
Brighton	194	?	53	6·3	3	281	?	68	9·4	0	223	?	47	7·2	0	248	?	51	8·3	1	946	?	54	7·8	4

* At stations marked with an asterisk the values are obtained by Jordan's Photographic Recorder; in all other places Stoke's instrument, or one of a similar construction is employed.

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TABLE III.—Duration of Bright Sunshine in various parts of the United Kingdom, March to June 1893—*Continued.*

Stations.	March.					April.					May.					June.					The Entire Period.				
	Total No. of Hours Recorded.	Diff. from Average.	Percentage of Possible Duration.	Mean Daily Amount.	No. of Sunless Days.	Total No. of Hours Recorded.	Diff. from Average.	Percentage of Possible Duration.	Mean Daily Amount.	No. of Sunless Days.	Total No. of Hours Recorded.	Diff. from Average.	Percentage of Possible Duration.	Mean Daily Amount.	No. of Sunless Days.	Total No. of Hours Recorded.	Diff. from Average.	Percentage of Possible Duration.	Mean Daily Amount.	No. of Sunless Days.	Total No. of Hours Recorded.	Diff. from Average.	Percentage of Possible Duration.	Mean Daily Amount.	No. of Sunless Days.
England, S. – *Continued.*	hrs.	hrs.	%	hrs.		hrs.	hrs.	%	hrs.		hrs.	hrs.	%	hrs.		hrs.	hrs.	%	hrs.		hrs.	hrs.	%	hrs.	
*Westbourne	224	?	61	7·2	3	302	?	74	10·1	0	248	?	52	8·0	0	245		50	8·2	2	1019	?	59	8·4	5
Southampton	209	+83	57	6·7	1	277	+114	67	9·2	0	256	+45	54	8·3	0	229	+ 25	47	7·6	1	971	+267	56	8·0	2
Scotland, W.																									
Glasgow	103	+22	28	3·3	5	180	+ 53	43	6·0	4	139	—21	28	4·5	4	215	+ 56	42	7·2	3	637	+1	35	5·2	16
Douglas (Isle of Man)	175	+55	48	5·6	2	245	+ 67	59	8·2	4	189	—35	39	6·1	3	263	+ 46	52	8·8	1	872	+133	49	7·1	10
England, N.W.																									
Newton Reigny	171	+71	47	·5	2	236	+ 95	56	7·9	2	170	—32	34	5·5	1	233	+ 41	46	7·8	0	810	+175	45	6·6	5
Stonyhurst	162	+64	45	5·2	8	224	+ 88	54	7·5	2	177	—16	36	5·7	3	207	+ 22	41	6·9	1	770	+158	43	6·3	14
Blackpool	146	+52	40	4·7	?	214	+ 70	51	7·1	3	170	—31	35	5·5	3	228	+ 39	45	7·6	0	758	+130	43	6·2	?
*Manchester	135	?	37	4·4	4	194	?	47	6·5	2	161	?	33	5·2	3	189	?	38	6·3	1	679	?	38	5·6	10
Llandudno	155	+64	43	5·0	3	207	+ 69	50	6·9	1	182	—10	37	5·9	4	264	+ 8	53	8·8	1	808	+208	46	6·6	9
England, S.W.																									
Pembroke	174	+44	48	5·6	2	250	+ 67	61	8·3	1	224	+ 9	47	7·2	1	272	+ 38	55	9·1	0	920	+158	53	7·5	4
*Tenby	187	?	51	6·0	4	268	?	65	8·9	1	242	?	50	7·8	1	271	?	55	9·0	0	968	?	55	7·9	6
Cullompton	195	+76	53	6·3	3	268	+123	65	8·9	0	213	+20	45	6·9	1	275	+ 81	56	9·2	0	951	+300	55	7·8	4
*Torquay	210	?	58	6·8	2	279	?	68	9·3	0	229	?	48	7·4	0	294	?	61	9·8	0	1012	?	58	8·3	2
Newquay	192	?	53	6·2	3	261	?	64	8·7	0	228	?	48	7·4	3	331	?	68	11·0	0	1012	?	58	8·3	6
Falmouth	209	+79	57	6·7	3	270	+ 97	66	9·0	0	254	+38	54	8·2	2	314	+ 89	65	10·5	1	1047	+303	60	8·6	6
Plymouth	208	+77	57	6·7	4	276	+107	67	9·2	0	233	+26	49	7·5	0	308	+105	64	10·3	0	1025	+315	59	8·4	4
Ireland, N.																									
Markree Castle	88	—13	24	2·8	7	164	+ 14	39	5·5	5	126	—61	26	4·1	1	215	+ 57	43	7·2	0	593	— 3	33	4·9	13
Armagh	121	+28	33	3·9	5	182	+ 43	44	6·1	3	126	—59	26	4·1	1	191	+ 20	38	6·4	1	620	+ 32	35	5·1	10
Arley Cottage	117	?	32	3·8	6	173	?	41	5·8	3	127	?	26	4·1	0	180	?	36	6·0	1	597	?	34	4·9	10
Ireland, S.																									
Dublin	158	+43	43	5·1	2	236	+ 74	57	7·9	1	175	—38	36	5·6	0	218	+ 33	44	7·3	0	787	+112	45	6·5	3
Parsonstown	123	+ 9	34	4·0	9	190	+ 30	46	6·3	2	127	—61	26	4·1	0	159	— 16	32	5·3	4	599	— 38	34	4·9	15
Valencia	113	—20	31	3·6	9	209	+ 39	51	7·0	2	182	—28	38	5·9	2	227	+ 29	46	7·6	3	731	+ 20	42	0	16
Channel Islands.																									
*Guernsey	228	?	63	7·4	2	289	?		9·6	0	303	?	65	9·8	0	331		69	11·0	0	1151	?	67	9·4	2
Jersey	222	+73	61	7·2	3	296	+108	72	9·9	0	291	+48	62	9·4	0	344	+110	72	11·5	0	1153	+339	67	9·5	3

* At stations marked with an asterisk, the values are obtained by Jordan's Photographic Recorder; in all other places Stokes' instrument, or one of a similar construction, is employed.

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over four months, while in the Channel Islands the sun actually shone during this lengthy interval for more than two-thirds of the time it was above the horizon. A careful examination of the records since the year 1881 shows no such spell of fine weather, the only approach to it being in the splendid summer of 1887, when the percentage at Jersey for the three months June, July, and August was over 60. The value, however, for that period was

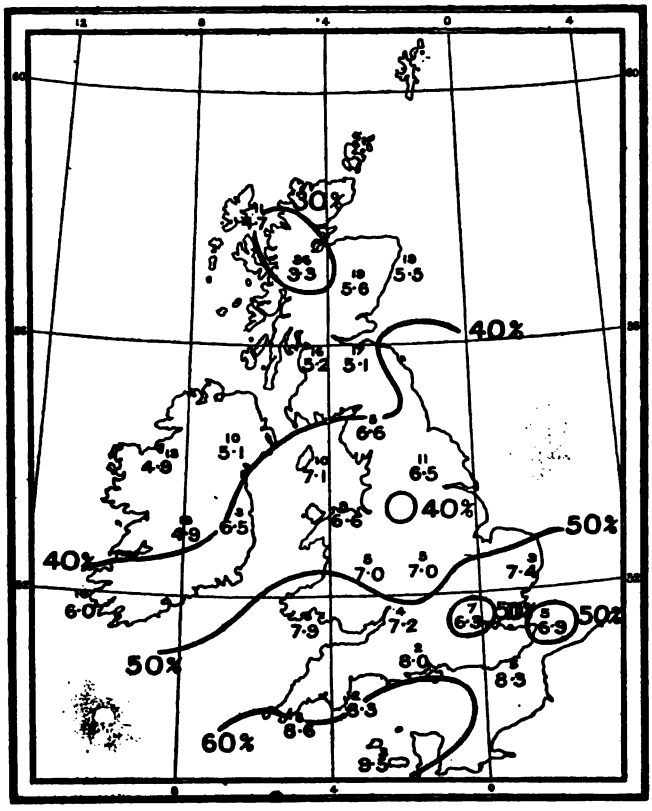

FIG. 8.
Percentage of Bright Sunshine, March to June 1893.

NOTE.—The percentage of possible sunshine is shown by the thick lines. The small figures represent the number of sunless days, and the ordinary figures give the mean daily proportion of bright sunshine.

lower than it was this year, and if, to make the comparison complete, we add either May or September, as a fourth month, to the 1887 record, we get a very much smaller percentage than that given in the period under discussion. As regards the daily proportion of sunshine, it appears that during the four months there was more than 7 hours per day in the midland counties, about 7½ hours in England East, and between 8 and 8½ hours on our south and south-west coasts, while in the Channel Islands the daily proportion for the entire period was no less than 9½ hours. The smallest number of sunless

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days in the four months was 2 at Southampton, Torquay and Guernsey, and 3 at Rothamsted, Dublin and Jersey, but many other stations over the southern parts of the Kingdom reported only 4 or 5 such occasions. In the Channel Islands, and also at Torquay and Plymouth, there was not one sunless day during the whole of April, May, and June.

Rainfall and the Drought.

The principal facts relating to the rainfall of the period are given in Table IV., which has been compiled from the returns furnished by 78 stations situated in various parts of the United Kingdom and published in the *Weekly Weather Report*. At the commencement of the inquiry the author was tempted to avail himself of observations made at a number of additional places, but on further reflection it appeared that while the inclusion of these would probably have led to the discovery of interesting local peculiarities, the additional labour involved in the search would have resulted for the most part in a simple accumulation of facts. The stations employed are fairly well distributed over the Kingdom, and the general survey they give of the actual state of affairs seems to be sufficiently complete for all practical purposes. The table shows for each month and for the entire period,—firstly, the number of rainy days experienced at each station; secondly, the total fall; and thirdly, the proportion of the average amount expressed in the form of percentages. The averages employed are mainly those for the 25 years 1866-90. Statistics relating to the drought are also included in the table. An explanation of the method on which these figures are drawn up will follow when we come to deal with the drought itself. For the present it will be sufficient to consider the question of the rain.

Rainfall.

In the course of our remarks on the distribution of barometric pressure attention was more than once drawn to the singularly local character of many of the rains experienced, some localities being favoured with fairly large amounts, while neighbouring places escaped with but a slight sprinkling or perhaps with no rain at all. This peculiar feature in the weather of the period comes out very clearly in the monthly values given in Table IV. A careful examination shows that in nearly every month, and in nearly every district, the rainfall at one of the stations in the district amounted to twice or more than twice that recorded at some other station in the same district, while in many instances the discrepancy was even more striking. Owing to these local variations our remarks on the rainfall of each month are necessarily of a somewhat general character.

In March the rainfall was below the average at all but one of the 78 stations. The single exception was Glencarron, a station situated in one of the wettest parts of Scotland, and here, owing to one or two heavy falls which took place during the early part of the month, the aggregate amount was nearly half as much again as the average. Most of the other stations in the same district (Scotland N.) had three quarters or more of the normal

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TABLE IV.—Amount of Rainfall experienced over the British Islands during the Months of March, April, May, and June, 1893, with the Proportion of the Average Amount, and Statistics relating to the Long Drought.

Stations.	March.			April.			May.			June.			The Entire Period.			Duration of Drought.						
																Absolute Drought.			Partial Drought.			
	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	Began.	Ended.	Duration in Days.	Began.	Ended.	Duration in Days.	Total Rainfall in Period.
Scotland, N.		Ins.	%		Ins.	%		Ins.	%		Ins.	%		Ins.	%							Ins.
Sumburgh Head	23	2·51	90	17	1·20	58	16	1·46	85	10	0·60	30	66	5·77	67	..	..	..	May 28	June 26	30	0·21
Stornoway	17	1·84	49	19	1·12	42	19	1·51	58	14	1·24	44	69	5·71	48	..	..	..	..	..	..	..
Wick	17	1·32	65	12	0·96	57	11	1·39	82	12	1·09	63	52	4·76	67	..	..	..	Mar. 18	April 17	31	0·23
Lairg	19	2·32	78	15	1·86	82	18	1·49	69	12	1·10	46	64	6·77	69	..	..	..	..	..	..	..
Glencarron	20	9·14	146	18	3·51	82	18	3·84	83	19	2·24	43	75	18·73	92	..	..	..	..	..	..	..
Fort Augustus	19	2·23	75	14	1·61	79	12	1·23	59	13	1·26	57	58	6·33	68	..	..	..	..	..	..	..
Fort William	20	4·44	73	14	3·12	88	15	2·73	75	12	1·89	47	61	12·18	70	..	..	..	..	..	..	..
Scotland, E.																						
Nairn	13	0·81	48	12	1·19	94	13	1·03	64	11	1·91	112	49	4·94	79	..	..	..	..	..	..	..
Aberdeen	10	0·68	29	14	0·81	38	16	1·32	66	12	3·52	199	52	6·33	77	Mar. 18	April 1	15	Mar. 9	April 16	39	0·39
Braemar	9	0·57	23	10	1·26	53	12	1·07	47	11	2·73	114	42	5·63	59	..	..	..	Mar. 11	April 14	35	0·31
Ochtertyre	10	0·91	33	6	0·96	41	11	1·23	50	7	3·15	116	34	6·25	61	Mar. 31 June 7	April 14 June 21	15 15	Mar. 16	April 14	30	0·07
Leith	8	0·60	43	9	1·15	73	11	1·55	93	8	1·76	98	36	5·06	78	June 7	June 21	15	Mar. 2 April 18	April 14 May 16	44 29	0·27 0·26
Marchmont	9	0·95	39	12	1·28	53	13	1·76	75	10	3·08	123	44	7·07	73	..	..	..	Mar. 4	April 14	42	0·40
England, N.E.																						
Alnwick Castle	8	0·70	30	9	0·54	24	15	1·19	55	11	1·41	76	43	3·84	44	..	..	..	Mar. 2	April 15	45	0·36
Durham	9	0·43	20	8	0·37	17	12	2·33	114	11	0·81	43	40	3·94	48	..	..	..	Mar. 2	May 1	61	0·61
Shields	7	0·84	48	7	0·33	18	11	1·31	78	9	1·04	61	34	3·52	51	Mar. 27	April 14	19	Mar. 2 May 23	May 15 June 21	75 30	0·69 0·28
Scarborough	5	0·18	10	6	0·61	31	12	1·44	74	12	1·65	86	35	3·88	50	Mar. 17	April 14	29	Mar. 4	April 28	56	0·54
York	7	0·32	18	7	0·48	27	11	1·91	103	9	1·25	58	34	3·96	53	..	..	..	Mar. 1	April 15	46	0·43
Spurn Head	7	0·29	24	3	0·18	12	10	1·19	76	8	1·13	73	28	2·79	48	..	..	..	Feb. 27	May 16	79	0·75

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TABLE IV.—Amount of Rainfall experienced over the British Islands during the Months of March, April, May, and June, 1893, with the Proportion of the Average Amount, and Statistics relating to the Long Drought—*Continued.*

Stations.	March.			April.			May.			June.			The Entire Period.			Duration of Drought.						
																Absolute Drought.			Partial Drought.			
	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	Began.	Ended.	Duration in Days.	Began.	Ended.	Duration in Days.	Total Rainfall in Period.
England, E.		Ins.	%		Ins.	%		Ins.	%		Ins.	%		Ins.	%						.	Ins.
Hillington	5	0·27	16	3	0·11	6	7	0·65	35	8	1·56	72	23	2·59	35	Mar. 17	April 15	30	Mar. 4	June 3	92	0·87
Yarmouth	9	0·44	24	5	0·13	8	8	0·80	43	11	1·10	59	33	2·47	34	May 2	May 16	15	Feb. 28	May 20	82	0·75
Geldeston	6	0·27	17	3	0·11	7	8	1·28	75	10	1·17	72	27	2·83	44	Mar. 19	April 11	24	Feb. 28	May 20	82	0·61
Cambridge	6	0·34	24	3	0·13	8	8	0·89	47	9	1·06	48	26	2·42	34	Mar. 18	April 15	29	Mar. 2	May 27	87	0·84
Rothamsted	7	0·35	20	3	0·22	10	8	1·20	55	8	0·97	43	26	2·74	33	Mar. 23 April 30	April 15 May 14	24 15	Mar. 1	May 16	77	0·68
Midland Counties.																						
Bawtry (Hesley Hall)	6	0·33	19	4	0·30	18	10	1·92	93	7	1·24	55	27	3·79	49	June 5	June 20	16	Mar. 2	May 16	76	0·63
Loughborough	7	0·30	18	4	0·34	19	9	2·40	115	7	0·89	40	27	3·93	51	Mar. 18 June 5	April 15 June 21	29 17	Mar. 1 May 21	May 16 June 21	77 32	0·77 0·22
Stamford (Ketton Hall)	7	0·24	17	4	0·43	22	10	0·76	31	9	1·00	52	30	2·43	31	Mar. 18	April 15	29	Mar. 1	May 16	77	0·76
Cheadle	11	0·78	34	4	0·53	25	10	2·28	96	8	1·40	48	33	4·99	51	..	..	..	Mar. 7	April 15	40	0·33
Churchstoke	8	0·51	25	5	0·19	10	12	2·34	108	11	1·14	53	36	4·18	51	..	..	..	Mar. 3 May 24	May 14 June 21	73 29	0·68 0·19
Hereford	5	0·27	16	4	0·17	9	8	2·20	105	10	1·07	50	27	3·71	48	Mar. 17	Mar. 31	15	Feb. 26	May 14	78	0·70
Cirencester	7	0·25	12	2	0·07	3	7	1·48	67	13	1·05	45	29	2·85	32	April 2	April 16	15	Feb. 26	May 14	78	0·72
Oxford	5	0·18	11	3	0·06	3	7	0·84	43	11	0·77	35	26	1·85	25	Mar. 17	April 15	30	Feb. 27	May 16	79	0·67
England, S.																						
London	8	0·39	26	4	0·10	5	8	0·47	25	9	0·87	41	29	1·83	25	Mar. 17 June 7	April 15 June 21	30 15	Feb. 28	June 21	114	1·09
North Foreland	6	0·36	?	0	..	0	7	1·12	?	5	0·52	?	18	2·00	?	Mar. 22	May 14	54	Feb. 28 May 22	May 20 June 22	82 32	0·82 0·32
Strathfield Turgiss	9	0·37	24	2	0·12	7	10	1·01	56	14	0·80	40	35	2·30	32	Mar. 17	April 15	30	Mar. 1 May 24	May 16 June 21	77 29	0·67 0·28

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TABLE IV.—Amount of Rainfall experienced over the British Islands during the Months of March, April, May, and June, 1893, with the Proportion of the Average Amount, and Statistics relating to the Long Drought—*Continued.*

Stations.	March.			April.			May.			June.			The Entire Period.			Duration of Drought.						
																Absolute Drought.			Partial Drought.			
	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	Began.	Ended.	Duration in Days.	Began.	Ended.	Duration in Days.	Total Rainfall in Period.
England, S.—*Continued.*		Ins.	%		Ins.	%		Ins.	%		Ins.	%		Ins.	%							Ins.
Dungeness	6	0·23	13	1	0·01	1	6	0·39	22	10	0·37	23	23	1·00	14	Mar. 18 April 17	April 15 May 15	29* 29	Feb. 27	July 3	127	1·27
Hastings (St. Leonard's)	6	0·38	20	1	0·02	1	7	0·63	35	9	0·91	55	23	1·94	26	Mar. 18 April 17	April 15 May 14	29† 28	Mar. 2	June 4	95	0·93
Southampton	5	0·26	13	2	0·07	3	6	0·84	41	8	1·03	54	21	2·20	27	Mar. 17 April 30 May 21	April 15 May 14 June 4	30 15 15	Feb. 28 May 21	May 16 June 21	78 32	0·73 0·31
Hurst Castle	7	0·66	36	0	..	0	6	0·80	45	7	0·84	44	20	2·30	31	Mar. 18 June 6	May 15 June 21	59 16	Feb. 28 May 21	May 16 June 25	78 36	0·72 0·28
Stowell	10	0·69	?	4	0·14	?	11	1·15	?	15	1·63	?	40	3·61	?	Mar. 17	April 15	30	Mar. 3	May 16	75	0·75
Scotland, W.																						
Laudale (Loch Sunart)	21	3·47	53	13	1·85	46	20	2·81	71	9	0·60	12	63	8·73	45	..	..	..	..	..	..	..
Glasgow	9	1·40	56	8	1·37	63	14	3·07	128	7	1·56	58	38	7·40	76	June 7	June 21	15	Mar. 17	April 14	29	0·20
Ardrossan	14	1·34	55	8	1·87	87	14	1·99	85	8	1·26	51	44	6·46	69	June 7	June 21	15	Mar. 17	April 14	29	0·27
Glenlee	13	2·71	69	9	1·39	48	13	2·82	95	10	2·03	63	45	8·95	69	..	..	..	Mar. 17	April 15	30	0·22
Douglas (Isle of Man)	11	1·05	37	6	1·28	55	13	1·43	66	8	1·45	67	38	5·21	55	April 1	April 15	15	Mar. 4 May 23	April 15 June 22	43 31	0·31 0·25
England, N.W.																						
Newton Reigny	8	1·67	75	5	0·41	22	10	1·57	77	9	2·08	100	32	5·73	70	..	..	..	Mar. 17	May 16	61	0·53
Stonyhurst	14	1·70	49	8	0·81	34	12	2·45	93	11	2·40	74	45	7·36	63	June 7	June 21	15	Mar. 17	April 15	30	0·27
Blackpool	8	0·79	35	4	0·37	22	10	1·74	85	7	1·27	60	29	4·17	51	Mar. 18 June 4	April 15 June 21	29 18	Mar. 7 May 21	May 14 June 21	69 32	0·68 0·21
Manchester	11	0·70	28	6	0·79	40	11	2·11	88	11	1·92	64	39	5·52	56	..	..	..	Mar. 17	April 15	30	0·27

* Drought interrupted by a fall of 0·01 inch on April 16.
† Do. Do. Do. 0·02 Do. Do.

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TABLE IV.—AMOUNT OF RAINFALL EXPERIENCED OVER THE BRITISH ISLANDS DURING THE MONTHS OF MARCH, APRIL, MAY, AND JUNE, 1893, WITH THE PROPORTION OF THE AVERAGE AMOUNT, AND STATISTICS RELATING TO THE LONG DROUGHT—*Continued.*

Stations.	March.			April.			May.			June.			The Entire Period.			Duration of Drought.						
																Absolute Drought.			Partial Drought.			
	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	Began.	Ended.	Duration in Days.	Began.	Ended.	Duration in Days.	Total Rainfall in Period.
ENGLAND, N.W.—*Continued.*		Ins.	%		Ins.	%		Ins.	%		Ins.	%		Ins.	%							Ins.
Liverpool Obs. (Bidston)	9	0·55	32	4	0·50	32	14	1·62	88	8	1·54	81	35	4·21	60	..	..	..	Mar. 3	April 15	44	0·33
Llandudno	7	0·77	39	5	0·87	48	11	1·75	97	7	2·14	118	30	5·53	74	April 1	April 15	15	Mar. 4	April 15	43	0·30
Holyhead	8	0·73	32	6	0·86	45	10	1·24	65	12	1·25	63	36	4·08	51	April 1	April 15	15	Mar. 4	April 15	43	0·27
ENGLAND, S.W.																						
Llandovery	10	0·80	22	3	0·11	4	12	2·32	82	12	2·43	82	37	5·66	46	..	..	..	Mar. 4	April 30	58	0·43
Pembroke	11	0·47	20	5	0·32	16	10	0·76	37	7	0·65	34	33	2·20	26	June 7	June 23	17	Mar. 7	May 15	70	0·68
																			May 21	June 25	36	0·17
Arlington (N. Devon)	9	0·92	26	3	0·20	7	11	2·10	71	7	1·43	44	30	4·65	37	April 2	April 21	20				
																May 24	June 12	20	Mar. 16	May 14	60	0·58
Cullompton	7	0·44	18	3	0·17	7	11	2·31	106	8	0·93	40	29	3·85	40	April 2	April 21	20	Mar. 1	May 14	75	0·72
																			May 21	June 21	32	0·29
Falmouth	7	0·54	16	2	0·06	2	7	0·67	24	8	1·21	47	24	2·48	21	Mar. 17	Mar. 31	15				
																April 6	April 28	23	Mar. 2	June 22	113	1·06
																May 23	June 11	20				
Plymouth	8	0·26	10	3	0·65	27	9	1·65	80	7	0·84	42	27	3·40	37	May 31	June 21	22	Mar. 1	April 21	52	0·34
																			May 20	June 25	37	0·37
Prawle Point	7	0·18	9	3	0·79	38	7	0·80	51	6	0·73	46	23	2·50	35	April 2	April 21	20	Feb. 27	April 21	54	0·51
																April 30	May 15	16	May 19	June 24	37	0·36
																May 24	June 12	20				
IRELAND, N.																						
Malin Head	16	1·33	?	7	1·16	?	13	1·22	?	11	1·40	?	47	5·11	?	..	..	..	Mar. 17	April 14	29	0·27
Londonderry.....	17	2·14	77	8	1·21	53	15	1·35	57	11	2·06	81	51	6·76	68	..	..	..	..	..	..	..
Edenfel (Omagh)	17	1·71	72	7	1·59	75	11	1·30	56	14	1·87	72	49	6·47	69	April 1	April 15	15	..	..	..	..
Belmullet	16	1·80	?	14	1·80	?	15	2·22	?	15	2·07	?	60	7·89	?	..	..	..	Mar. 18	April 15	29	0·25
Markree Castle.....	16	1·55	62	12	1·58	64	15	1·53	75	12	2·54	84	55	7·20	72	..	..	..	..	..	..	..

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TABLE IV.—Amount of Rainfall experienced over the British Islands during the Months of March, April, May, and June, 1893, with the Proportion of the Average Amount, and Statistics relating to the Long Drought—*Continued.*

Stations.	March.			April.			May.			June.			The Entire Period.			Duration of Drought.						
																Absolute Drought.			Partial Drought.			
	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	No. of Rainy Days.	Total Rainfall.	Percentage of Average Amount.	Began.	Ended.	Duration in Days.	Began.	Ended.	Duration in Days.	Total Rainfall in Period.
		Ins.	%		Ins.	%		Ins.	%		Ins.	%		Ins.	%							Ins.
Ireland, N.—*Continued.*																						
Brookeborough	14	1·43	51	7	0·97	38	13	1·63	65	13	2·83	98	47	6·86	64	..	..	..	..	..	..	..
Armagh	11	1·00	48	11	0·94	44	13	1·12	55	9	1·59	75	44	4·65	55	June 7	June 22	16	Mar. 17	April 15	30	0·22
																			Mar. 17	April 15	30	0·23
Donaghadee	13	0·74	36	7	1·16	60	11	0·99	44	12	1·65	86	43	4·54	56	..	..	..	May 24	June 21	29	0·28
Edgeworthstown	14	1·01	36	6	1·00	43	11	2·47	101	12	2·68	89	43	7·16	68	April 1	April 15	15	Mar. 17	April 15	30	0·30
Ireland, S.																						
Dublin	8	0·29	14	7	1·05	52	10	1·67	84	12	1·72	93	37	4·73	59	April 1	April 15	15	Feb. 26	April 15	49	0·42
Parsonstown	10	0·61	26	7	0·76	37	11	2·82	126	8	2·54	106	36	6·73	75	..	..	..	Mar. 16	April 15	31	0·29
Kilkenny	10	0·38	18	7	0·69	32	12	2·31	116	9	1·83	83	38	5·21	61	June 7	June 21	15	Mar. 1	April 15	46	0·41
Waterford	7	0·56	18	4	0·62	24	11	1·59	67	8	1·66	69	30	4·43	42	April 1	April 15	15	Mar. 4	April 15	43	0·34
																June 7	June 21	15				
																Mar. 16	Mar. 30	15*				
Roche's Point	5	0·12	3	5	1·57	49	11	2·54	81	6	1·87	60	27	6·10	46	April 1	April 15	15	Mar. 1	April 16	47	0·24
																June 7	June 24	18				
Valencia	17	1·23	29	9	1·09	28	11	1·79	56	13	2·07	63	50	6·18	43	..	..	..	..	..	..	..
Killarney	9	0·68	?	11	1·28	?	9	0·98	?	12	1·53	?	41	4·47	?	..	..	..	..	..	..	..
Foynes	9	0·44	?	8	1·34	?	8	1·26	?	12	1·51	?	37	4·55	?	..	..	..	..	..	..	..
Channel Islands.																						
Scilly (St. Mary's)	7	0·34	14	2	0·18	8	7	0·61	35	5	0·63	34	21	1·76	21	April 2	April 20	19	Mar. 1	May 17	78	0·60
																June 4	June 22	19	May 20	June 24	36	0·33
Jersey	12	0·61	26	2	0·34	16	9	1·79	96	5	0·58	30	28	3·32	41	Mar. 19	April 10	23	Mar. 7	May 15	70	0·69
																April 23	May 13	21	May 21	June 25	36	0·34
																May 24	June 12	20				

* Drought interrupted by a fall of 0·01 inch on March 31.

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quantity, but at Stornoway the total fall was only 49 per cent. of the average. In the west of Scotland and the north of Ireland the rainfall, though less abundant than it was further north, amounted to more than half the average, the largest percentage values in these districts being 77 at Londonderry, 72 at Edenfel (Omagh), and 69 at Glenlee. At Newton Reigny also, situated on the borders of England N.W., the fall amounted to 75 per cent. of the average. With the exception of these extreme north-western and northern stations the rainfall in March amounted in all cases to less than half the average, while over a considerable portion of England as well as in the south of Ireland it was less than one quarter of the normal amount. The driest station of all was Roche's Point, where the total rainfall (0·12 in.) amounted to only 3 per cent. of the average. Next to this came Prawle Point with 9 per cent., Plymouth and Scarborough with 10 per cent., and Oxford with 11 per cent. Over a considerable portion of our eastern, central, and southern counties there was no rain at all after the middle of the month.

In April the absence of rain was upon the whole far more striking than in March, a deficiency being reported in all parts of the Kingdom. At the extreme northern and north-western stations the deficiency was somewhat small, over 60 per cent. of the average being reported at several of the stations in Ireland N., and over 80 per cent. at three out of the seven stations in Scotland N. and at one station in Scotland W. At Nairn (in Scotland E.) there was as much as 94 per cent. of the normal quantity. At many of the stations situated in the north-west of England and the south of Ireland the rainfall of April exceeded that of March, but over England generally the weather was very much drier. Over our eastern, southern, and south-western counties, and also in the more southern parts of the midland district, the total fall amounted to less than one tenth of the average, while in many places the proportion was very much smaller. The driest region of all was undoubtedly the extreme south; at Hastings the month's rainfall amounted to only 0·02 in., and at Dungeness to 0·01 in., while at the North Foreland and Hurst Castle there was no rain at all.

In May the weather was far less dry than in either March or April, an actual excess of rain being reported at several stations over central and northern England, as well as at Glasgow and in many of the central Irish districts. In the east and south of England there was again a large deficiency, less than half the average being reported at the majority of stations. The driest localities of all were Dungeness with 22 per cent. of the normal amount, Falmouth with 24 per cent., and London with 25 per cent.

In June the deficiency of rain was more general than in May, the only district in which the values were above the average being the east of Scotland; at Aberdeen the amount was nearly double the normal. At the majority of stations situated in the central and southern parts of England, and also in the west and north of Scotland, the amounts were less than half the normal, the smallest proportion of all (12 per cent.) being reported, singularly enough, at Laudale on Loch Sunart, a district famous for heavy rains. Over England

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the smallest percentage values were 23 at Dungeness, 30 at Jersey, and 34 at Pembroke and Scilly.

Taking the period of four months as a whole, the figures show, as one would naturally expect, that there was a deficiency of rain in all parts of the Kingdom, the only station at which the fall approximated to the average being Glencarron, where the percentage reached 92. In the east and south of Scotland the fall amounted to more than three-fourths of the average, and in the west of Ireland it was not very much short of the same proportion. The districts in which the rainfall failed to reach one half of the average amount comprised all the more southern and eastern parts of England, with the extreme south of Ireland and a portion of Durham and Northumberland. A similar deficiency was also reported in the west of Scotland, at the two stations Stornoway and Laudale. Over the southern counties of England generally the fall amounted to less than one third of the average, the only stations at which this proportion was exceeded being those in more central parts of Devonshire. In London and at Oxford there was exactly one quarter of the average quantity, while at Pembroke there was very little more than one quarter. The driest localities of all were, however, those situated in the extreme south-east and south-west of England. At Scilly and Falmouth the total fall amounted to only 21 per cent. of the average, while at Dungeness the percentage value was as low as 14, the fall for the whole four months being less than one seventh of the usual quantity. The smallest number of days with rain was at the North Foreland, where there were only 18, next to this we find Hurst Castle with 20, Southampton and Scilly with 21, and Hillington, Dungeness, Hastings, and Prawle Point with 23.

In order to test the truth of the general impression regarding the very exceptional character of the period, the records made over a long series of years in London and at Oxford have been examined. For the Metropolis recourse has been had to the Meteorological Office records extending back to the year 1865, and prior to this to the Rainfall values for the London district published some years since by Mr. G. Dines. The latter extend back as far as the year 1813, but as they are compiled from returns kept at a number of stations in the neighbourhood of the Metropolis, they are not strictly comparable with observations made at a single station. The record is, however, generally held to be the most complete and reliable one in existence. For Oxford the records published by the Radcliffe Observatory, which extend back to the year 1851, have been used.

The London record for more than 80 years past fails to show any period of four months at any season with so small a rainfall as that of the present year. In the period under discussion the total for the four months in London was only 1·88 in., the nearest approach to it being in the months of October 1879 to January 1880, when the total was 2·17 ins.

The Oxford record, for 42 years past, also contains no such an amount as that recorded in the period under discussion. The nearest approach to it was in the months of January to April 1892, when the total was 2·50 ins.;

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after which come, as in London, the four months October 1879 to January 1880, with a total of 2·54 ins. In 1893 the fall was only 1·85 in. It seems not a little singular that one of the driest periods on record should have occurred in 1879, a year which was remarkable for bad weather, and in which the rainfall for the entire twelve months was largely in excess of the average.

The Drought.

The drought statistics, given in Table IV., are drawn up on the basis of the definitions laid down by Mr. Symons in *British Rainfall* for the year 1887. These definitions are as follows:—

1. *Absolute Drought.* Periods of more than 14 consecutive days without any measureable quantity of rain.

2. *Partial Drought.* Periods of more than 28 consecutive days the aggregate rainfall of which does not exceed 0·01 in. *per diem.*

In addition to these an *Engineer's* drought was defined as a period of three or more consecutive months the aggregate rainfall of which is less than one half the average.

Table IV. clearly shows that an Engineer's drought prevailed to a greater or less extent in all the more southern parts of England, as well as at some stations situated in the south of Ireland and the west of Scotland. In many places the three months' limit might indeed be multiplied by two. In London and at Oxford, for example, the deficiency of rain was prolonged over seven months, the total fall between March and September being only slightly over 48 per cent. of the average at Oxford, and rather less than 46 per cent. in the Metropolis. At many other stations in the south of England the rainfall of July was sufficiently heavy to terminate the long drought.

Turning now to the statistics relating to the drought in its absolute and also in its partial sense, we see from the table that the only portions of the United Kingdom altogether unaffected were the western stations in Scotland N. and several of the northern and south-western stations in Ireland, or, speaking generally, the extreme western and north-western parts of the United Kingdom. At two of the stations in Ireland N., viz. Malin Head and Belmullet, there was a partial drought lasting for 29 days, while in the Shetlands and Caithness there was one lasting for 30 or 31 days. Two other stations in Ireland N. experienced an absolute drought continuing for 15 or 16 days, and a partial drought lasting over 30 days. In Scotland E., and in the more northern and eastern parts of Ireland S., the drought was fairly general, the returns from the former district showing in many cases an absolute drought extending over 15, and a partial drought lasting over 35 days; at Leith there were two partial droughts, one lasting for 44 and the other for 29 days. In the northern and eastern parts of Ireland S. there were one or two absolute periods, and at Roche's Point as many as three, the partial spells extending over periods ranging from 31 days at Parsonstown to 49 at Dublin. Most of the stations in Scotland W. experienced an absolute

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drought for 15 days, and a partial drought ranging in most cases between 29 and 31 days. At Douglas, Isle of Man, however, there were two partial periods,—one of 43 and the other of 31 days. In England N.W. three stations out of the seven had an absolute drought lasting for 15 days, while at another station (Blackpool) there was one absolute period of 29 and another of 18 days. The partial drought in England N.W. varied greatly in duration in different places; at Stonyhurst and Manchester there were only 30 days, but at Newton Reigny there were as many as 61, while at Blackpool there was one period of 69, followed after a week's interval by another of 32 days. Similarly large variations were reported in the north-east of England, for while four stations out of the six escaped an absolute drought, one other station had 19 days without rain, and another station as many as 29 days. All parts of the district reported a partial drought, the number of days ranging from 45 at Alnwick Castle, and 46 at York, to 79 at Spurn Head, and to 75, followed by another 30 day period, at Shields.

Coming now to the districts more seriously affected, we find in the first place that in the midland counties six stations out of eight experienced an absolute drought, the number of days ranging from 15 at Hereford and Cirencester to 30 at Oxford. At Loughborough there was one period of 29 days between March and April, and another period of 17 days in June. The partial drought lasted in most places from 75 to 79 days, while at Loughborough and Churchstoke this very long period was supplemented by a shorter one, which continued respectively for 32 and 29 days.

In the east of England all stations were affected both in an absolute and also in a partial degree. At Yarmouth the length of the absolute drought was only 15 days, but at all other stations it exceeded 20, and at Hillington it reached 30 days. At Rothamsted there was one long period of 24 followed by a shorter one of 15 days. The partial drought in the eastern counties lasted for over 30 days at four out of the five stations, the longest spell being at Hillington, where it extended over 92 days.

In the south-western counties of England the drought, though less continuous than in the eastern districts, was upon the whole rather more severe. In place of one long period of intensely dry weather, there were in most cases two or three, each lasting for 15 or 20 days. At Falmouth there was one absolute drought of 15 days in March, followed by another of 23 in April, and by a third of 20 between May and June. The partial drought was also divided by intervals of copious rainfall, excepting at Falmouth, where it lasted continuously over a period of 118 days. In most of the cases there was one long drought lasting between 50 and 70 days in the early part of the period, followed by a shorter one of about 35 days between the months of May and June.

The district most affected was, however, undoubtedly the south of England, or rather that portion of it bounded by Dorsetshire in the west, Wiltshire, Berkshire, and Middlesex in the north, and Kent in the east. In an absolute degree the severity of the drought varied in different localities, some places being exposed to one long period of rainless weather, while others

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experienced two or even three spells of a shorter duration. The longest absolute period was at Hurst Castle, where there were 59 consecutive days without rain, next to which comes the North Foreland with 54. At Dungeness and Hastings the absolute drought would have lasted as long as at Hurst Castle had it not been for some showers which fell on April 16th; at the former station these only yielded 0·01 in., and at Hastings 0·02 in., but they were

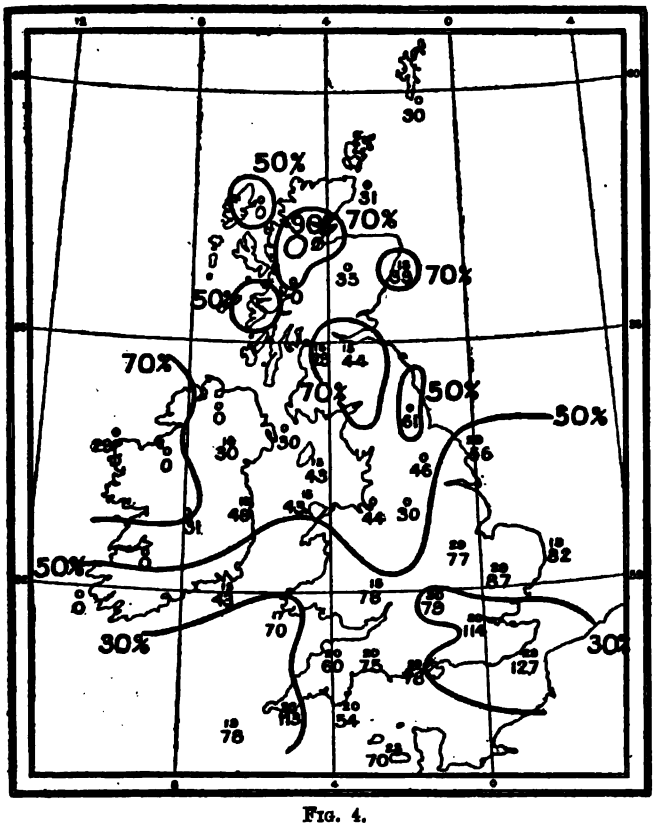

FIG. 4.
Proportion of average amount of Rainfall, March to June 1893.

NOTE.—The percentage of the average amount of Rainfall (in percentage form) is shown by the thick lines. The small figures show the duration in days of the longest *absolute* drought, and the ordinary figures give the duration of the longest *partial* drought.

quite sufficient to interrupt the rainless period, which would otherwise have lasted for 59 and 58 days respectively. In London, and also at Strathfield Turgiss, Southampton, and Stowell, the longest period of rainless weather lasted for 30 days, but in the Metropolis it was followed in June by another spell of 15 days. The period of partial drought was also interrupted in many cases by some copious rains which fell during the latter part of May. At four stations out of the eight given in the district there was one long period ranging between 77 and 82 days, followed by a shorter one ranging between 29 and 36 days.

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TABLE V.—Droughts experienced in London since the Year 1865.

Absolute Drought.			Partial Drought.			
Began.	Ended.	Duration in Days.	Began.	Ended.	Duration in Days.	Total Rainfall in Period.
						Ins.
1865. June 3	June 28	26	.....	None ..	..	....
„ Sept. 22	Oct. 7	16	.....	.....	..	....
1866.....	None	..	.....	None ..	..	....
1867.....	None	..	Oct. 28	Nov. 29	33	0·33
1868. June 5	June 19	15	.....	None ..	..	....
„ June 24	July 10	17	.....	.....	..	....
„ Aug. 27	Sept. 15	20	.....	.....	..	....
1869. June 22	July 7	16	June 18	July 27	40	0·34
„ Aug. 17	Sept. 4	19	.....	.....	..	....
1870. Apr. 11	April 25....	15	Mar. 27	April 27	32	0·32
„ Sept. 14	Oct. 2	19	April 11	May 10	30	0·30
„	.....	..	May 14	June 15	33	0·19
1871.....	None	..	Oct. 22	Dec. 18	58	0·55
1872. Aug. 10	Aug. 24	15	.....	None ..	..	....
1873.....	None	..	Nov. 30	Dec. 29	30	0·29
1874. Apr. 18	May 2	15	Jan. 25	Feb. 24	31	0·28
„	.....	..	April 14	May 21	38	0·21
1875.....	None	..	Mar. 8	April 5	29	0·22
1876. May 1	May 21	21		None ..	..	....
1877. Sept. 22	Oct. 6	15	Sept. 11	Oct. 9	29	0·27
1878.....	None	..	.....	None ..	..	....
1879. Dec. 6	Dec. 26	21	Nov. 22	Dec. 29	38	0·36
1880. Jan. 17	Feb. 4	19	April 20	May 30	41	0·39
„ Mar. 8	Mar. 30	23	Aug. 8	Sept. 10	34	0·22
„ May 12	May 26	15	.....	.....	..	....
„ Aug. 9	Aug. 23	15	.....	.....	..	....
1881. Mar. 25	April 10....	17	.....	None ..	..	....
1882. Jan. 12	Jan. 28	17	Jan. 9	Feb. 13	36	0·30
„ Mar. 27	April 11	16	.....	.....	..	....
„ July 28	Aug. 11	15	.....	.....	..	....
1883. Mar. 31	April 17....	18	Mar. 20	April 17	29	0·13
„ May 27	June 14....	19	July 24	Aug. 30	38	0·32
1884. June 10	June 28....	19	May 6	June 3	29	0·29
„ Dec. 21	Jan. 4, 1885	15	July 28	Aug. 26	30	0·30
„	.....	..	Sept. 7	Oct. 5	29	0·26
1885. July 20	Aug. 4	16	July 12	Aug. 19	39	0·31
1886. June 23	July 10	18	.....	None ..	..	....
1887. Apr. 6	April 20....	15	Feb. 3	Mar. 10	36	0·28
„ June 9	July 8	25	June 4	July 14	41	0·18
1888.....	None	..	.....	None ..	..	....
1889.....	None	..	.....	None ..	..	....
1890.....	None	..	....	None ..	..	....
1891. Feb. 7	Feb. 28....	22	Jan. 31	Mar. 6	35	0·14
1892. Mar. 28	April 12....	16	.....	None ..	..	....
„ Dec. 15	Dec. 31	17	.....	.....	..	....
1893. Mar. 17	April 15....	30	Feb. 28	June 21	114	1·09
„ June 7	June 21	15	.....	.....	..	....

At another station, Stowell in Dorsetshire, the longer period was alone experienced, while at the three remaining stations there was one very long period exceeding in duration anything experienced in other parts of the district. At Hastings the partial drought continued for 95, while in London it lasted for as many as 114 days. The longest spell of all was,

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however, at Dungeness, where the number of days amounted to no fewer than 127, the period commencing with February 27th and ending with July 3rd.

The general state of affairs relating to the rainfall and drought of the entire four months is graphically shown in Fig. 4, which gives, firstly, the percentage of the average rainfall in the different parts of the Kingdom, and secondly, by figures, the duration of the drought at certain selected stations. To avoid overcrowding the map I have, in cases where two or more droughts prevailed, chosen only the longest. The information is therefore less complete than that given in the table.

In order to obtain some idea of the exceptional character of the weather of the period, a list has been prepared (Table V.) giving the duration of all the absolute and partial droughts experienced in London since the year 1865. The table is based entirely on the London observations given in the *Daily Weather Report*.

A very superficial examination of the figures is sufficient to shew that, both in an absolute and also in a partial degree, the drought of 1898 was considerably longer than any other recorded in the course of the past 29 years. The nearest approach to the period of 80 rainless days experienced this year was in June 1865, when a drought extended to 26 days. Next to this came 1887 with a period in June and July extending to 25 days, and March 1880 with a drought of 23 days. The partial drought of 114 days recorded this year was nearly twice as long as any other in the 29 years, the nearest approach to it being 58 days between October and December 1871. Next to this, but a long way behind it, came April and May 1880, and June and July 1887, each with a partial drought of 41 days, and afterwards June and July 1869, with a period of 40 days. It may be of interest to note that in the course of the whole 29 years there were only five years in which neither an absolute nor a partial drought was reported, and it is rather singular to observe that three out of the five were consecutive. No drought was experienced in London either in 1888, 1889, or 1890. The year with the longest number of absolute droughts was 1880, with four such periods ranging in duration from 15 to 23 days. The longest number of partial droughts was three in the years 1870 and 1884, but in each case the duration was very slightly in excess of the minimum laid down by Mr. Symons in his definition.

In conclusion I have to express my best thanks to the Meteorological Council for their kindness in allowing me to make use of a large quantity of unpublished data. I have further to acknowledge the valuable assistance rendered by my friend, Mr. A. J. Rigby, of the Meteorological Office, who has verified most of the computations.

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DISCUSSION.

Mr. G. J. SYMONS said that with regard to the distribution of pressure as indicated in Mr. Brodie's isobaric charts, there was a remarkable similarity between the direction of the normal isobars for the northern part of the British Isles and those shown in the chart for the period covered by Mr. Brodie's paper. He (Mr. Symons) had repeatedly stated that the exceptional features of the past season were almost entirely confined to the southern portion of England, and a line drawn across the country from Falmouth to Boston would roughly cut off the area over which weather of an exceptional character was experienced. It appeared to him very desirable that an investigation such as Mr. Brodie's should be made to embrace the continent of Europe; and indeed it appeared probable that it would be necessary to include the whole of the world, as he knew that in other countries, notably in the United States, weather of very exceptional character had been experienced. It was the duty of meteorologists to ascertain the reason for these remarkable irregularities in the weather, and he hoped that some of the men of ability who were now turning their attention to meteorological problems would be able to devote their time and energies to the work of discovering the cause of such exceptional conditions as those which have prevailed during the present year.

Dr. A. BUCHAN drew attention to the fact that in the southern seas during last spring and early summer icebergs had been seen nearer the equator than had ever been known previously, and it was exceedingly probable that this phenomenon had some connection with the exceptional weather experienced in so many parts of the world. Icebergs had been observed off the Chatham Islands, east of New Zealand, where they had never been seen before. He believed that if a map were constructed showing at as many places of observation over the world as possible, the variations of the actual atmospheric pressure during the past season from the normal, no attempt being made to reduce the pressures to sea level, we should be on the way towards understanding the causes which had been at work in producing the abnormal weather of the present year. With regard to the prevalence of drought, he considered that the distribution of thunderstorms was an important factor in connection with the prevalence of drought, and we had yet to learn why certain districts were more liable to thunderstorms and their attendant rainfall than were others. An examination of the data from Ben Nevis showed that all periods of excess of temperature and great drought occurred with anticyclonic conditions, this fact seeming to point to the existence of an upper stratum of air of higher temperature and greater density than the lower stratum. The weather experienced in the British Islands depended upon the distribution of pressure in their vicinity, the presence of anticyclonic conditions over our islands resulting in the prevalence of magnificent weather, such as had been experienced during the present year.

Mr. B. LATHAM said that the drought had been spoken of as a thing of the past, but it was likely that the community would feel its effects upon water supply for some time into the future. It was curious that the very wet year of 1879 was followed by a year of drought, and if there had been no excess of rain in 1879 England would have suffered greatly from scarcity of water. Similarly, when the drought discussed by Mr. Brodie commenced the springs were very high, probably higher than ever before, the exceptionally heavy rainfall during February having made provision for the period of drought which ensued. Since February, however, the level of water in the springs had been gradually declining, and during the past eight months no rain had passed through his percolation gauge at Croydon. It was a remarkable fact that, in spite of the warmth and dryness of the past season, the amount of evaporation from a surface of water had been much less than usual; and this somewhat unexpected result was, he thought, to be ascribed to free evaporation being interfered with by the film of smoke and dirt which collected on the water surface in dry weather, whereas rainy weather kept the surface clear of these impurities. One of the important lessons learned from the drought had been to discover that, although the rain which had fallen during the period had not percolated through the percolation gauge, it had been sufficient to raise the water level in large reservoirs. He thought that we were now experiencing the lowest water period

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of the year, and that if a change did not soon take place the consequences were likely to prove serious.

Mr. C. HARDING said that he had lately been working out the mean summer and winter temperatures and rainfall at Greenwich during the last fifty years, and had also prepared a statement of the number of warm and cold days. These figures showed that in the six months, April to September, of the present year, the temperature was 70° or above on 106 days; in 1865 there were 127 days; while 1846 and 1869 each had 108 days. Temperatures of 80° or above were registered on 29 days in 1898; 1868 had 40 days; and 1846, 1851, and 1859 each had a large number. The mean temperature for the period was 60°·6, the average being 56°·8, or almost 4° less; only two other years, 1865 and 1868, had a mean temperature exceeding 60°. As regards rainfall, the six months' fall amounted to 7·89 ins., the driest year in the fifty being 1870 with 6·80 ins. In 1879, a very wet year, the fall for the six months amounted to as much as 22·03 ins. One of the extraordinary features of the past summer, so far as London was concerned, was the extremely warm night on August 18th, when the minimum temperature at Brixton was as high as 72°. The mean temperature on that day was 81°·2, and was a long way in excess of any mean daily temperature during the past fifty years. The large quantity of ice which had been met with in the South Atlantic was a most interesting feature when considered in connection with recent weather, for such immense bodies of ice would probably exert a considerable effect upon the distribution of pressure, and it was the relative position of areas of high and low barometer that controlled the weather. Another curious fact was that captains of ships crossing the equator had almost all drawn attention to the presence of an easterly current there in the earlier months of the year, such a current in that portion of the Atlantic being quite unknown before.

Dr. A. BUCHAN inquired whether any attempt had been made to eliminate the effect of surrounding hills upon the records of sunshine, as in some localities a considerable proportion of sunlight must be cut off by adjacent hills.

Mr. R. H. SCOTT said that in England and Ireland the places supplied with sunshine recorders by the Meteorological Office were carefully selected in order that the recorder should command a free horizon; and, as far as he recollected, in only two cases, those of Valencia and Llandudno, were the records seriously interfered with by surrounding hills. In his Report on *Ten Years' Sunshine in the British Islands* there would be found a description of the exposure for all the stations included in that Report.

Mr. G. J. SYMONS remarked that it would be a comparatively easy matter to correct sunshine records affected by neighbouring hills. It certainly appeared desirable that something should be done in that direction, but by far the best plan was to select stations for which no correction was required.

Mr. F. GASTER said that, while agreeing with those speakers who had pointed out the desirability of discovering the reason for the abnormalities discussed in Mr. Brodie's paper, he at the same time realised the enormous difficulties which such an investigation involved, and was hardly surprised that nobody had yet ventured to enter upon so great an undertaking. He drew attention to the manner in which the remarkably warm days in April were developed, the exceedingly genial weather at inland places appearing to be entirely due to the intensity of the sunshine, for the temperature of the Easterly current on our coasts at the time was only from 1° to 2° above the average, and people who had gone to the seaside to recruit their health were obliged to remain indoors and have fires lighted because of the keenness of the wind. Inland, however, such was the warming effect of the brilliant sunshine, that it was possible to sit out of doors and enjoy the fine weather. The great dryness of the air was also a very noticeable feature, and one which morning and evening observations quite failed to adequately indicate. In considering the distribution of rainfall, it was necessary to remember that there were three distinct classes of rainfall, viz. 1st., general rain which prevailed with large rain-bearing currents; 2nd, thunderstorm rains, generally very local and the limits sharply defined, so much so that it frequently happened in such cases that the rainfall recorded in London at stations north and south of the Thames differed materially; and 3rd, partial rains falling copiously over large areas of country, rarely accompanied with thunder, and generally occurring with an Easterly wind in summer and a Westerly wind in winter. He had

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carefully examined the lists of maximum falls of rain given in Mr. Symons's annual volumes of *British Rainfall*, and found that all of them had occurred with Easterly winds in summer and with Westerly winds in winter. This appeared to him to be a very striking fact, and he thought it would be desirable when discussing rainfall data to classify the figures not according to years but according to the class of rainfall to which they belonged.

Mr. H. SOUTHALL said that in the neighbourhood of Ross the drought was more felt in September than in the earlier part of the year, and he had been told by a farmer that there was practically no grass whatever in that district.

Mr. F. BRODIE, in reply, said that he fully agreed with Mr. Symons and the other speakers who had urged the desirability of discussing the weather over a much larger area than the British Islands, but it was impossible for him to carry out such an investigation, the leisure time at his disposal being so very limited. He had only undertaken the compilation of the present paper because he felt that such a remarkable season should not be passed over without some special notice being taken of it, and as it appeared likely that no one else was doing the work he had undertaken it.

Mr. W. ELLIS, in a communication to the Secretary, said:—It may be of interest to give some particulars for the months of March to June, as observed at the Royal Observatory, Greenwich, in order to show the variation from averages as determined from long series of observations. Four values are in each case given, which will be understood to apply to the months of March, April, May, and June respectively. The mean maximum temperature was 56°·9, 64°·2, 70°·6, and 75°·8, above the average by 7°·2, 7°·0, 6°·5, and 4°·4; the mean minimum temperature was 35°·9, 39°·6, 46°·1, and 50°·1, above the average by 0°·9, 0°·7, 2°·4, and 0°·2; the mean daily range was 21°·0, 24°·6, 24°·5, and 25°·2, above the average by 6°·8, 6°·8, 4°·1, and 4°·2; the mean temperature was 46°·2, 51°·4, 57°·7, and 61°·8, above the average by 4°·5, 4°·2, 4°·6, and 2°·4. The averages referred to are those for the 50 years 1841-1890. The temperature rose to 80°, or above, once in April (80°·0 on April 20th), once in May, and seven times in June, being once above 90° (91°·0 on June 19th). In the 50 years, 1841-90, there is no instance of a temperature of 80° so early as April 20th, the earliest being April 27th, 1865, 81°·5. The rainfall in the four months was 0·433 in., 0·119 in., and 0·580 in., and 0·822 in., below the average of the same 50 years by 1·028 in., 1·542 in., 1·478 in., and 1·200 in., in all 5·248 ins. in defect in the four months. The mean amount of cloud was 4·0, 3·1, 5·7, and 4·8, values all below the average of the 70 years ending 1887; the lowest previous values for this period for March and April being 5·0 in March 1841, and 3·7 in April 1840. The hours of sunshine were 155·1, 61·6 above average, 231·0, 119·5 above average, 186·5, 9·9 above average, and 198·0, 24·7 above average, these averages being for the 15 years 1877-1891. The mean relative humidity was 74, 67, 66, and 65 respectively.

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THUNDER AND HAIL STORMS OVER ENGLAND AND THE SOUTH OF SCOTLAND, JULY 8th, 1893.

By WILLIAM MARRIOTT, F.R.Met.Soc.

[Read November 15th, 1893.]

Saturday, July 8th,—two days after the Duke of York's wedding—was a day of remarkable meteorological phenomena, for the temperature over the south and east of England rose above 80°; thunderstorms prevailed over the greater part of England and Scotland; hailstones of immense size fell at numerous places; and squalls or whirlwinds swept up the valley of the Nith and along the coast of Lincolnshire, on the latter capsizing a boat at Skegness whereby 29 lives were lost.

In the morning thunderstorms occurred in Yorkshire and Durham between 6.30 and 11 a.m.; and also over Dorset, Hampshire, Gloucestershire, Worcestershire, and Shropshire between 7 and 10.30 a.m. These storms were not of great intensity.

In Cumberland and the south-west of Scotland severe thunderstorms occurred between 10 a.m. and noon.

About noon a thunderstorm, accompanied by heavy hail and a violent squall of wind, passed over Dumfries and along the valley of the Nith as far north as Closeburn.

The following account is taken from the *Dumfries and Galloway Standard and Advertiser*:—

"About 11 a.m. on Saturday the serenity of the day was sharply and suddenly broken by a thunder shower, which quickly emptied the streets of pedestrians. An hour later, following upon several peals of thunder, there was a strong rush of wind up the valley, from the South-west; and simultaneously with it there occurred a fall of hailstones which were quite commonly the size of large marbles, and fell in such quantities that they lay piled together in little ridges along the foot pavements. Right up from the Solway the path of the wind was marked by overturned stampcoles of hay, and clouds of leaves were driven before it. On Nethertown of Troqueer some thirty ricks were swept before the blast; and on Flatts of Cargen and other farms in the same neighbourhood it played equal havoc with the work of the harvesters. At Cherrytrees persons who were out had to seize hold of a fence to enable them to stand against the force of the wind, and in one field a donkey was pressed by it against the wall. In Dumfries it stripped a number of slates from the roofs; empty boxes which were lying about were swept before it; in Leafield saw mills a long plank was caught and projected to the other side of the workshop; and in Queensberry Square it lifted the covering from the stall of a vendor of crockery. Continuing its frolicsome career north of the town, the blast levelled more than twenty ricks on the farm of Lincluden. On M'Cheynestone and other farms in Dunscore it played similar fantastic tricks; and it strewed the braes of Kirkmahoe and Closeburn with similar tokens of its strength. So suddenly did the storm burst that a number of boys bathing in the Nith at Dumfries were obliged to run up the Sands with their clothes under their arms to find shelter from the pelting of the hail-

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stones. The force of the wind here seemed to turn the river and cause it to run up the channel. The hail-shower did not continue for quite a quarter-of-an-hour, but during that time the rattle of the stones upon windows resembled a continuous fusilade of musketry; and in that short space of time it provided a week's work for a good staff of glaziers.

"While reports show that the thunderstorm and accompanying rain were very general over Dumfriesshire and the Stewartry—extended indeed over a great part of Scotland—the hail and wind storm was restricted to a limited area, covering a comparatively narrow band along the valley of the Nith as far north as Closeburn. It is strikingly illustrative of its local nature that while the hailstones caused some injury to the conservatory at Marchfield, there were none at Dalscone, little more than a hundred yards along the same road. On the Lochmaben road the hail was not experienced beyond Brownrigg. The villages of Collin and Locharbriggs lay outside its range, although at Kirkland, Branetrig, and other Torthorwald farms some ricks were overturned by the wind; and on the Stewartry side Lochfoot was beyond the area of the exceptional storm. Many of the hailstones were a peculiar shape, flat and roughly circular, with a white core, surrounded by clear ice, and another white portion forming the outer coating. Their appearance strikingly suggested that of a blind eye. Others were nearly spherical or slightly elongated, like a pigeon's egg. They all showed clearly a composite character, resulting from the aggregation of several pieces of ice. The size varied considerably at different places along the route of the storm. In the neighbourhood of Kirkbean they were relatively small, although, driven as they were by the force of the wind, they were sufficient to prevent horses from facing the storm and to cause their drivers to seek speedy shelter.

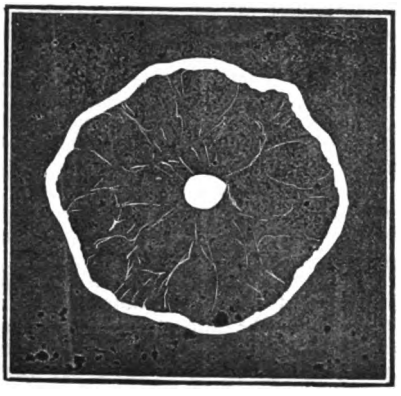

FIG. 1.

Section of Hailstone (actual size) which fell at Dumfries.

"The large hailstones showed a remarkable formation: the nucleus was of opaque white ice about the size of a pea: this was surrounded by perfectly clear ice, the clear ice being apparently an aggregation of separate hailstones closely compacted round the nucleus with a thin coating of white ice; this latter may have been owing to attrition."

At Dumfries they commonly approached the size of pigeons' eggs or good sized marbles. Many measured from an inch to an inch and a half in length. One which was tested was found to be an inch and three quarters in length and seven-eighths of an inch in depth. In another instance where a measurement was made one of the stones was found to be two inches and a half in circumference. A number picked up at random on High Street were found to weigh on an average a quarter of an ounce. Mr. Gibson, grocer, St. Michael Street, who had experience of a somewhat similar storm early in the thirties, states that one placed in his scales was an ounce and a half in weight. In Kirkmahoe the stones seem to have obtained their greatest size. One of circular shape and not

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exceptional size measured two inches and a tenth in diameter. Another measurement reported was five and three quarter inches in circumference. Occasional pieces of ice fell of even larger dimension than those regarding which an exact record was kept.

In Dumfries there was a wholesale destruction of glass, particularly of roof lights and of windows where the frontage was to the west, from which direction the storm proceeded when it reached its climax."

Mr. P. Dudgeon, F.R.S.E., of Cargen, has kindly favoured me with a sketch of one of the hail stones (actual size) which he picked up in Dumfries. This is shown in fig. 1.

Peterborough Storm.

The following account is taken from the *Peterborough Advertiser*, July 15th :—

"Shortly before noon on Saturday one of the severest storms ever remembered at Peterborough broke over the city, and did a considerable amount of injuiry. The storm came from the south-east, and was preceded by an insufferable closeness of the atmosphere. For some time before the storm burst an unusual darkness prevailed, while the whole of the south-eastern sky was of a lurid red colour. As the storm approached and the rain began to fall the city became enveloped in a dense mist, while there were frequent and vivid flashes of forked lightning, followed by short claps of crashing thunder. The mist gradually increased in density, so that it was almost impossible to see across some of the streets, and at the same time a violent tempest of wind began to rage. The mist was so dense that the railway signals could not be distinguished, and to prevent accidents the men at the level crossings closed the gates across the road. This was succeeded by the most phenomenal hailstorm ever witnessed in the city. The hailstones descended in clouds, and were of enormous size. Many of them were weighed by Messrs. Heanley and Saunders, and also by Mr. S. Wilson, and were found to weigh about 24 grains each. Many of them measured an inch across, the greater number were lozenge shaped, but others were of a triangular section. The average measurement was from three-quarters of an inch to a half in diameter. The rain also increased and descended in torrents, and what with the gale, which twisted trees about into violent contortions, the rain, the fearful and almost incessant flashing of lightning, followed by the crashing peals of thunder, a scene of unusual wildness was created. The streets were quickly flooded, and there was hardly a house in the city which was not more or less invaded by the rushing water, which hardly fell like rain, but more as if a waterspout were being emptied over the city. The roar of the wind, the rattling of the bullet-like hailstones, the rolling thunder, and the rushing of the water together created such a noise as to drown all else. Fortunately, however, the tempest did not last long.

"At Paston a man took refuge under a tree, but finding the storm increasing with terrific violence, he left the tree and ran to a shed a short distance off. He had no sooner left the tree than a flash of lightning shivered it to pieces from the top to the bottom. Several other trees close to were also struck and dismembered. In many cases where the trees were struck the trees themselves or huge branches were carried by the gale a considerable distance. A brewery chimney in St. Leonard's Street was struck by lightning, and partially destroyed, one of the chimneys at the Great Northern Hotel was also struck by lightning, a chimney at Brook Villa, Brook Street, was struck, and at the house of Mr. Scott, Eastfield Road, the gable end went in, but whether this was caused by the gale or by the violent reverberation of the thunder is not known. A flag-staff over the business premises of Messrs. Hawley, Jermyn, Smith and Co. snapped in two, and carried with it some telephone wires, which had the effect of temporarily blocking the traffic in Narrow Street. Horses and cattle in the streets and in the fields were seen to suffer under the infliction of the hailstorm in a serious manner. As illustrating the stinging force of the hailstones, it may be mentioned that some men got under a tarpaulin at Fengate, but the hailstones inflicted such pain, even through this covering, that the men found themselve

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compelled to abandon their tarpaulin for a more substantial shelter. It is also stated that a cart was standing in Cumbergate, and the force of the storm carried it half-way down the street. A large number of minor accidents happened, such as the upsetting of market stalls."

Between 1 and 2 p.m. a thunderstorm accompanied by a squall of wind passed along the Lincolnshire coast, and it was during this squall that the pleasure boat was capsized off Skegness.

From this time onwards till about 10 o'clock in the evening there was a succession of thunderstorms over the north-east of England and south-east of Scotland. From many places it is reported that the thunderstorms were continuous for 9 hours. The barographic traces show considerable oscillations during the whole of this time; so that it is probable that the observers were not able to distinguish between the different storms.

This has been a great drawback in investigating the individual storms, as *time* is a most important factor.

Two storms were remarkable for the immense hailstones which fell during their prevalence over the neighbourhood of Harrogate and Richmond in Yorkshire.

HARROGATE STORM.

The following is taken from the *Ripon Gazette*, July 13th :—

"The severe thunderstorm of Saturday last will be remembered for a long time to come, such a scene as that witnessed on Saturday afternoon not being within the recollection of some of the older inhabitants. At Harrogate the morning was warm and close, and thunder was repeatedly heard in the distance. As noon drew near, the air was very oppressive, and shortly after there was every indication of a heavy thunderstorm. A little before 2 o'clock the sky was thickly overcast with clouds. It was of a peculiar density and unlike ordinary thunderstorms. There was an evenness and almost a murkiness about the tone of the sky which one could hardly fail to remark. Then a blackness nearly approaching that of night descended, and rain became suddenly driven in an oblique direction with terrific force and in phenomenal quantities. The rain soon became thickly mingled with hail of extraordinary size, not to say of a hen's egg or even a cricket ball, as one imaginative writer has stated. The largest that came under our personal observation was 5 inches in circumference, others being 4 and 4½ inches. We have heard of a gentleman who picked one up 2 inches in diameter, and another of 2 oz. weight. On the Moor, we believe, the hailstones were larger than in the town. The rain was accompanied by vivid lightning and loud peals of thunder, and the storm, when at its height, continued from 10 to 15 minutes. During this period extensive damage was done to property in various parts of the town. Trees were blown down and thousands of feet of glass were destroyed. The low parts of the town were flooded for a short time on account of the drains being incapable of taking away the rain, which fell in torrents."

At Brimham Rocks many of the hailstones measured as much as 8 inches in diameter, and at Swincliffe, one was picked up which measured 5½ inches in circumference. I was in Harrogate two days after the storm and had ocular demonstration of its severity, for the majority of the windows having a south-easterly aspect—that is, facing the direction in which the storm came—were broken, as well as skylights and conservatories. Almost without exception in the houses of three floors, all the panes of glass in the top floor were broken, in the middle floor several panes were broken, but on the

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ground floor comparatively few panes were broken. There is no doubt that the hail was driven by the wind against the top of the houses with the greatest violence, and consequently most damage would be done there. The top storey panes were mostly small and probably of thin glass, while the ground floor windows consisted of only one or two panes, which were most likely of thicker glass than those above.

The extent of the damage caused by the hail may be gathered from the following note by Mr. J. Farrah, the Society's observer at Harrogate:—

"I have made inquiries amongst the glaziers of this district, and find that in a radius of five miles not less than 100,000 panes of glass were broken, the cost of which is about £3,000. A further £7,000 (taking the same radius) will, so far as I can learn, cover the damage to shrubs, flowers, grass, corn, turnip and potato crops. In this radius comparatively little corn is grown and very little fruit. The greatest acreage is in permanent pasture, from which the milk and butter supply of Harrogate is drawn; otherwise the devastation would have been much greater. I have seen some curious instances of the vagaries of the storm. In one garden the potato tops would be battered to the ground, whilst in an adjoining one they might be comparatively unhurt.

"Harlow Hill, which is situated a mile west of our meteorological station and is 600 feet above sea level, was in the vortex of the storm. The Nursery Gardens there were to a considerable extent wrecked; about 22,000 feet of glass was broken, and a large quantity of tomatoes and herbaceous plants destroyed.

"In the above estimate I have not taken into consideration the damage done by the water to premises where, through one cause or other, it reached the interiors. From my own knowledge this will amount to several hundreds of pounds.

"I was told by a farmer, who lives at Salter-gate Hill, three miles west of Harrogate, that some of the red clay tiles that cover his outbuildings were broken by the hailstones, and that partridges were picked up dead in the fields, having been killed by the same cause."

Dr. H. J. Johnston-Lavis made some drawings of the hailstones, which were published in *Nature*, Vol. 48, p. 294. By permission of the Editor these are shown in fig. 2.

Dr. Johnston-Lavis says:—

"At first a little rain fell, but it was soon mixed with small hailstones, about the size of peas of the usual form. These were quickly followed by hemispheres of the size and character indicated in *C* (fig. 2). After a few minutes they rapidly grew to the size of those shown in *A* and *B*, which were drawn very carefully to actual scale. Most were flattened oval discs, as shown in the two drawings, which exhibit top and side view of one hailstone. I went out myself and measured a good number while they were falling by putting them on a sheet of paper and marking their maximum and minimum diameters. These large stones usually had an opaque spherulitic-like nucleus, followed by two, three, and even a trace of a fourth, clear ice shell intervening with opaque ice. Then followed a broad band of clear ice with a few radiating air cavities, finally enclosed in a mass of white granular feathery ice. The number of alternating laminæ seemed to be irregular, and must have varied with that of the different

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vapour strata traversed by each nucleus. The origin of the type (*A* from *C*) is very obvious.

"The quantity that fell was enormous, so that a lawn badly kept was entirely white with the exception of the longer blades of grass that projected. The damage done in the near neighbourhood must amount to some thousands of pounds, and very few were the houses in this town that escaped without windows being broken."

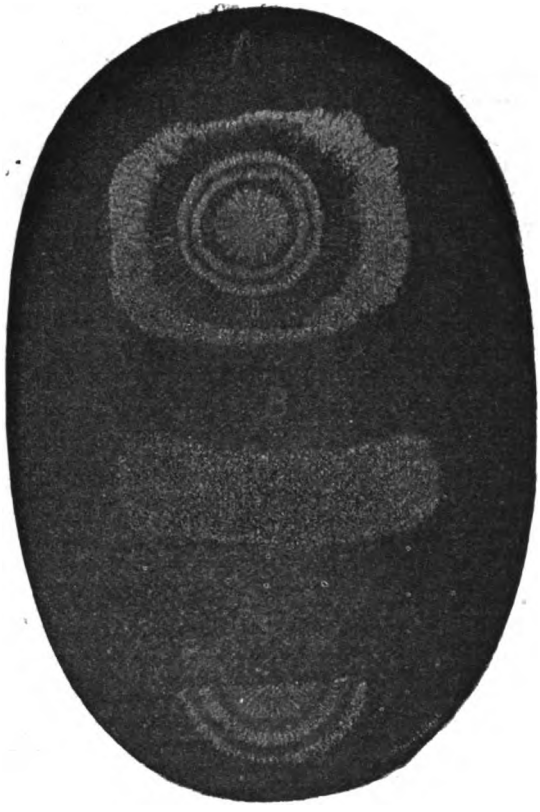

FIG. 2.

Sections of Hailstones (actual size) which fell at Harrogate.

RICHMOND (YORKS.) STORM.

The following account is taken from *The North Star*, July 10th:—

"Shortly after 2 o'clock on Saturday afternoon, Richmond and district was visited by a thunderstorm the violence of which has had no equal within the memory of the oldest inhabitant. During the morning the atmosphere was sultry, almost suffocating, and thunder was heard at intervals rumbling in the distance. About 2 o'clock the air became misty, and the peals of thunder were more audible. A few minutes later the sky all round was black, darkness set in, and the terrible storm began. Rain drops as large as a crown piece fell at first. These were succeeded by small hailstones, which rapidly increased in size until they became as large as bantam's eggs. A wind rose at the time, and these large missiles fell in a perfect deluge. A scene of the wildest confusion followed in the

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Market Place, for the market folk had not then started on their homeward journey Women and children screamed with fright, and ran into the nearest shops for shelter; but these did not afford them much protection, for the enormous pieces of ice shot through the windows like cannon balls. With such force did they fall that pots and ornaments on the opposite walls were smashed to pieces. The rattling of falling glass and pots, the vivid flashes of the lightning combined with the screams of the women and children and the heavy peals of thunder, formed a scene which will never be forgotten by those who witnessed it.

"Some of the pieces of ice were of very artistic shape. Others were round, two inches in diameter, and a quarter of an inch thick. These tapered in picturesque curves to a point in the centre, and the round edges looked as though they had been skilfully carved. Some were two inches long, half-an-inch in diameter, and were prettily marked, while others were simply blocks of ice of all sizes and descriptions. Some of these, which were weighed by many for curiosity, turned the scale at three and a half ounces.

"The damage done is enormous, and very few houses in the town have escaped without broken windows, while in many of the large houses not a single window remains unbroken. Most damage has been wrought among the greenhouses and the studios of the photographers. The conservatories at Bolton Crofts—Alderman Roper's, Dr. Carter's, and others—were all riddled through and through. The houses where windows faced the south and east suffered most. The bulk of the damage was done in Frenchgate, Millgate, Market Place, and Newbeggin. Skylights were shattered and fell crashing to the ground, greatly alarming the inhabitants. The studios of Messrs Riley, Metcalfe, and Sanderson, were wrecked.

"In the King's Head Hotel, no less than 175 panes of glass were smashed; at Mr. T. McGuinness's there were 147, and at the Wesleyan Chapel, there were 185 broken. At the Newbeggin side of the Roman Catholic Church, numbers of the small diamond-shaped windows were riddled through, and those in the Primitive Methodist Chapel were shattered. The sky-light over the magisterial quarters of the Town Hall, which is of very thick glass, was smashed to pieces. Considerable damage has been done to garden produce. Apples, plums, gooseberries, and currants were cut to pieces and strewed over the land. Small branches and leaves were cut off the trees, and the Queen's Road after the storm presented the appearance of a green field.

"The pieces of ice could be picked up in shovelfuls, and many of the houses were flooded. All the damage was wrought within the space of ten minutes"

I visited Richmond on August 17th, nearly six weeks after the storm, and from what I saw and heard I do not think that the above account is at all exaggerated. The storm came up from about south-east at 2.20 p.m., and was accompanied by a strong wind. The air was also very thick, being described "as dark as pitch." The hailstones were first about the size of marbles, and these were succeeded by the very large ones. All windows facing east to south were broken. The violence of the wind and the force with which the hailstones fell was clearly demonstrated by both glass and hailstones being hurled from the windows to the opposite sides of the rooms, and in one instance, which I measured, 25 feet along a passage. I was informed that a military officer saw the hailstones rebound to a height of 20 feet. I measured a tile ¾ inch thick, which had been broken by the hail, the fracture being 8¼ inches in diameter.

As hail fell at Bedale a short time before that at Richmond, it seems that the storm was developed a little distance south-east of Bedale, and that it increased in energy as it travelled along, and that its fury was not spent until it had swept beyond Richmond. The width of the storm was from two to three miles.

Nearly every one in Richmond was terribly scared by this storm, and

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many thought the world was coming to an end. There was one person, however, who did not lose his presence of mind, and that was Mr. H. J. Metcalfe, who collected a number of the hailstones, and succeeded in getting two photographs of them, actual size.[1] These are most interesting and instructive, as they show not only the shape and the size of the hailstones, but also in several instances their structure.

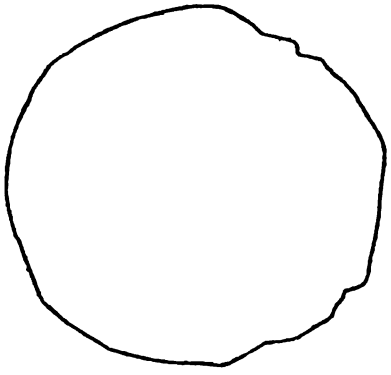

FIG. 3.

Outline of Hailstone (actual size) which fell at Belleisle, Richmond, Yorkshire.

Mr. M. Cooper, of York, made a drawing of two hailstones which he picked up in a bed room at Belleisle, about half-a-mile out of Richmond. The one shown in fig. 8 had been in the room some time before it was found, and consequently was reduced in size.

OTHER STORMS.

Between 4 and 5 p.m. violent hailstorms occurred in the neighbourhood of the Rivers Ouse and Wharfe. Large hailstones fell at Goole, Howden, and Selby, while at Snaith they are described as being "as large as plums," and at Tadcaster "as large as marbles."

During the afternoon a violent thunderstorm passed in an almost straight line from Normanby to beyond Darlington, that is to say from south-south-east to north-north-west. Its path, which followed very closely the main line of the North Eastern Railway, was clearly indicated by persons and cattle being struck by lightning.

A number of thunderstorms prevailed over the south-eastern counties during the afternoon. These travelled mostly in an easterly or north-easterly direction. Some hail fell at Crowborough.

A succession of violent thunderstorms also passed over the north-east of England and the south-east of Scotland during the afternoon and evening.

In the evening about 10 p.m. a thunderstorm passed along the north-west coast of England, which was accompanied by heavy rain.

[1] These photographs are given in the Hon. Rollo Russell's book *On Hail*. London, 1893.

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Barometrical Pressure.

From the *Daily Weather Report* at 8 a.m. it appears that there was a depression lying over the west of Ireland, the lowest barometer reading being 29·58 ins. at Valencia. The pressure increased to 30·0 ins. and upwards over nearly the whole of Scandinavia, Denmark and Germany, as well as in Spain, and to 30·1 ins. and upwards in the north of Norway. The gradients were consequently slight for Southerly and South-easterly winds.

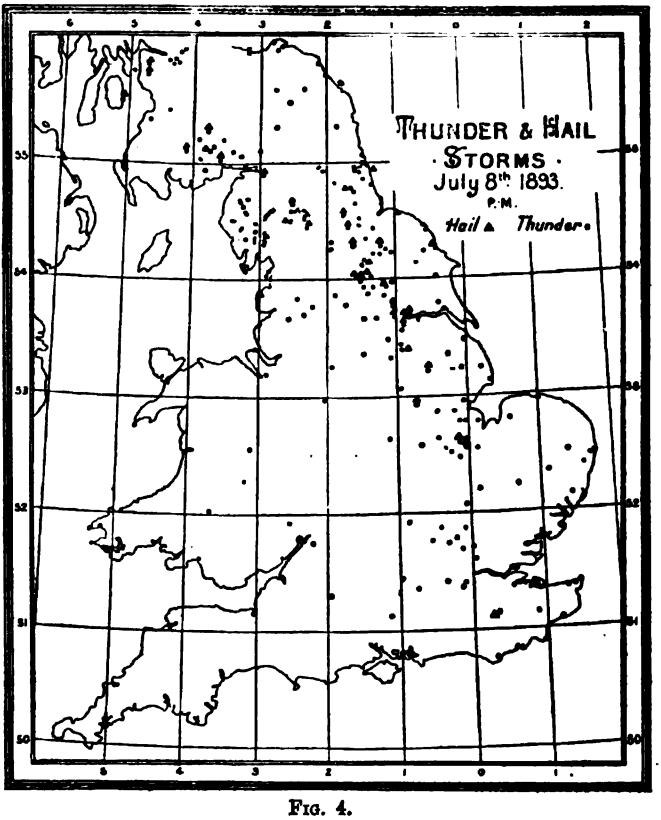

Fig. 4.

I endeavoured to prepare hourly charts from 8 a.m. to midnight, showing the distribution of pressure and the direction of the wind. I was not, however, successful, as the data available were insufficient for the purpose. By plotting on charts the changes in pressure from hour to hour, it appeared that the barometer was falling steadily over the greater part of England, but in Yorkshire and the south of Scotland considerable changes in pressure occurred, these changes being greatest and most numerous at the times of the occurrence of the thunderstorms. The barograph traces exhibited considerable oscillations at the times of the passage of the thunderstorms, that at Leeds (fig. 5) showing a remarkable rise of ·06 inch between 1 and 2 p.m., which was no doubt connected with the Harrogate storm.

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Rainfall.

Rain fell over the whole of England and Wales and the south of Scotland during the day; the amounts over the southern half of England were generally under a quarter of an inch. Over the north of England and the south of Scotland the rainfall for the most part exceeded half-an-inch; while along the north-east coast and part of the north-west coast, the north-west of Yorkshire, Durham, Northumberland, and part of the south-west of Scotland the rainfall was over an inch. At Durham the rainfall amounted to 2·42 ins.

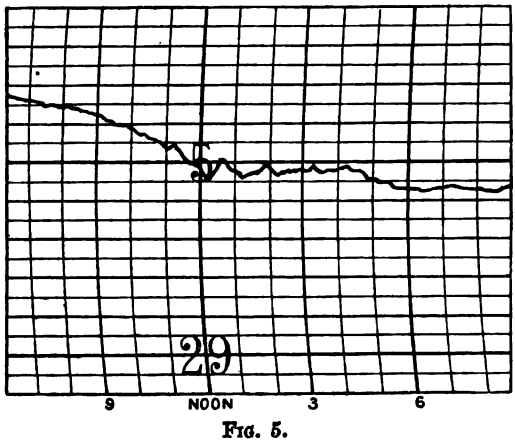

Fig. 5.

Barograph trace at Leeds, July 8th, 1893 (The clock was about 20 minutes slow).

Paths and Rate of Travel.

The storms in the northern part of the country travelled generally in a north-north-westerly direction at the rate of about 20 miles an hour. They appear to have taken the path of the least resistance, and consequently passed over low ground and along the river valleys and the sea coast. Several storms seem to have followed each other along the same track.

Lightning.

The lightning in some of the storms was very destructive, many persons and animals being killed. There are two cases which I wish to mention.

The first is that of a man named Rudd, at Harrogate, who had the crown completely taken out of his hat, though he himself was uninjured. The second is that of a man on a haystack who, when struck by lightning, was *lifted up* in the air, and then carried out against the wind, and fell to the ground like a stone. As this may have been the result of a discharge from the earth to the cloud, or what is sometimes called an "upstroke," I think it desirable to give the following report of the inquest from the *Peterborough Advertiser*, July 15th.

"Whittlesey. A Man Killed By Lightning.—During the great storm on Saturday William Smith, landlord of the 'Cross Guns,' was putting a tarpaulin on a haystack with two other men, when all three were struck by lightning, and

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Smith unfortunately was killed. An inquest was held at the 'Cross Guns' Inn, on Monday, by Mr. G. Carrick, deputy-coroner, on the body. Mr. E. C. Elderkin was foreman of the jury, The first witness was Samuel Lyon, labourer, who stated: I lived at Stowe, but at present am working for Mr. Keeble on his farm near the 'Cross Guns' Inn. I knew deceased and indentify the body just viewed by the jury as that of William Smith. He was I believe 48 years of age. On Saturday last I was working on Mr. Keeble's farm, and the deceased was working with me about a quarter to two in the afternoon. He and I were on the top of a haystack and a thunderstorm appeared to be coming up. We were engaged covering the stack with sheetings. Whilst so engaged a flash of lightning played round about us. The shock brought me on my knees. I was just speaking to him, and all of a sudden he appeared to be lifted off the top of the stack and fell on to the ground, at a distance of about 25 feet. The sheeting on the top of the stack was smoking as if struck by lightning. When the deceased fell I at once went to him. He was lying stretched out on the ground. The cloth cap now produced I saw about a yard from the deceased. It is rent open from the top to the edge. It has a slight mark as if of burning upon it. When I went up to him I undid his shirt collar and lifted him up. He gave no sign of life. I believe he was then dead.—Gideon Infield stated: I am a farmer and live at Ramsey, Hunts. On Saturday last, about a quarter to two, I was engaged carting hay for Mr. Keeble near the 'Cross Guns.' I was near the hay stack referred to by last witness, and he and deceased were upon the stack covering it up with sheeting, but had not then done so I had just finished my dinner, when a thunderstorm, accompanied by a high wind, came on. A flash of lightning passed me, which was immediately followed by another flash and a very loud peal of thunder. The second flash went in the direction of the deceased, and I saw it strike him at the back of the head, and the shock brought Lyon on his hands and knees, on the top of the stack. I saw the cloth cap now produced, and which deceased was wearing on his head when he was struck. The deceased was lifted up about 4 to 5 feet in the air in a perpendicular direction, and was then carried out against the wind for 8 or 10 yards, away from the stack, and fell to the ground like a stone. I was about 60 yards from the place, but hurried up to the deceased, who was lying stretched out on the ground. He never moved again. His pulse gave no sign of life.—Arthur Jordan Vialls stated: I am a police-constable in the Isle of Ely force, stationed at Coates. On Saturday afternoon last the death was reported to me of the deceased. I at once went to Keeble's farm, where I saw the dead body. I found a mark on the right side of the neck similar to that of a burn. It appeared to be recent. I examined the shoulder and chest without removing all the clothes, but saw no other marks or bruises. I saw the cloth cap which I now produce. It was lying on the deceased's face, and was in the same condition as it is now. It has a rent from the button on the top down the back to the edging.—A verdict was returned that deceased was accidentally killed by lightning. The only mark on deceased was the slight burn on the neck."

Formation of Hail.

In the drawings and photographs of the sections of the hailstones, there are several alternate coatings of opaque and clear ice. These coatings must be due to the revolutions accomplished by the hailstone which was probably drawn in towards the vortex of the storm several times. Ferrel, in his *Popular Treatise on the Winds*, gives the following explanation of the formation of hail (p. 423):—

"The origin of the hailstone is often not a rain drop, but a bunch of snow formed in the snow region, and moistened by the rain carried up into this region before it has had time to become frozen into hail. This moist snow is kept up there until it freezes, and after that, while being kept up there, and after it commences to fall, so long as its temperature remains below zero it continues to receive a coating of ice from the rain which is carried up past it and that through which it falls. As it grows and is carried outward above where the ascending current is weaker, it finally becomes too heavy to be kept sus-

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pended in the air, and falls to the earth a hailstone, with a *kernel of frozen snow in its centre*. In such a case we may imagine the soft ball of snow to have originated in the snow region at *m* (fig. 6) and then to have been kept partially suspended and to have been carried up and out slowly from the centre to a distance where it could drop down, having become meanwhile reduced to a low temperature, and that on its way down it received a coating of ice from the small ascending rain drops, or others with which it came in contact during its fall, and that it finally reached the earth at *n*.

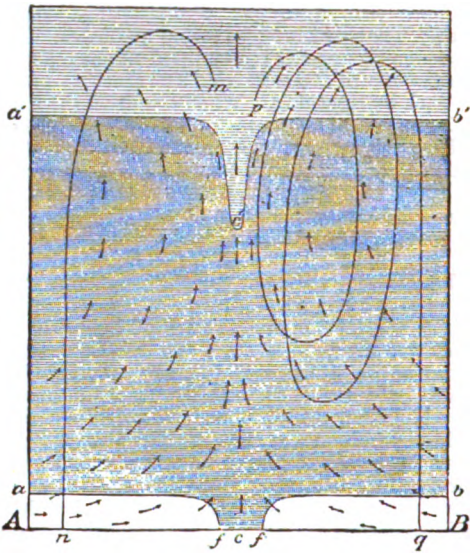

FIG. 6.

Ferrel's Theory of the Formation of Hail.

"It often happens, however, that in falling very gently where the ascending current at no great distance from the vortex is not quite, but nearly, sufficient to keep it suspended, it is drawn in again by the indrawing currents from all sides towards the vortex, as the scud clouds under the rim of the tornado cloud, where the ascending current is sufficient to carry it up again into the snow region, where it receives a coating of snow moistened by the small rain drops carried up into the snow region before they freeze. This coating now becomes frozen solid, and the whole mass, it may be, reduced considerably below zero temperature before it is carried out above, where it can gradually drop down again toward the earth; and in falling, even through the lower part of the snow region where there is little snow, but mostly rain drops not yet frozen, it receives another coating of solid ice; for its temperature having been reduced considerably below zero, it continues to freeze the rain coming in contact with it for a long distance after having passed down into the cloud region. But in gently falling down it may be drawn in a second time towards the centre and be carried up by the ascending current into the snow region and receive another coating of solid ice in the same manner as before. This process may be repeated a number of times, in each of which the hailstone, disregarding its gyratory motion all the while, describes a kind of orbit not returning into itself, somewhat as represented in fig. 6, until finally it is carried out above so far from the centre, or the strength of the tornado becomes so much weakened, that it is no longer carried in toward, and up in, the central part, but falls to the earth a *hailstone with a snow kernel and a number of alternating concentric coatings of solid ice and frozen wet snow*.

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"In this case we may suppose the small snowball to have originated at p and to have been carried up and out, and then to have fallen down and to have been drawn in toward the centre several times, until finally it was carried out so far, and had grown to be so heavy that it was not brought in toward the centre, but dropped down to the earth at q."

The above explanation seems to account for the numerous alternate coatings of opaque and clear ice in the large hailstones. In each of the storms in which hail fell, the same characteristics were reported, viz. great darkness, squall of wind, severe thunderstorm, and heavy rain. All these seem to show that the air was in violent agitation favourable for the production of large hailstones.

In conclusion, I would remark that the results of this investigation confirm those set forth in my "Report on the Thunderstorms of 1888 and 1889."

THE GREAT STORM OF NOVEMBER 16th-20th, 1893.

By CHARLES HARDING, F.R.Met.Soc.

[Read December 20th, 1893.]

The storm which forms the subject of this paper was so disastrous both with respect to loss of life and property on our seas, as well as having occasioned considerable loss and suffering on shore, in addition to the vast destruction of timber, especially over the northern portion of the Kingdom, that it seems desirable that some account of its occurrence should appear in the *Quarterly Journal* of the Society.

For a few days prior to the storm a large area of high barometric pressure spread from the neighbourhood of Iceland, over Great Britain and the North Sea, to central Europe. This high pressure system moved steadily to the south-eastward, while a small disturbance reached us from the Atlantic and advanced eastwards up the English Channel and to Germany during November 14th and 15th.

This pilot disturbance caused a partial giving way of the high pressure area over western Europe, but on November 16th high barometer readings had again asserted themselves over Russia, and doubtless the re-establishment of anticyclonic conditions over central Europe had a most important influence on the track of the storm, which was at that time within so short a distance of our western coasts.

The earliest intimation of the approach of bad weather, in connection with the storm which forms the subject of this paper, was shown at Valencia at 4 p.m. on the 15th, when the barometer commenced to fall and the wind an hour or so afterwards began to freshen from the South-east. The Meteo-

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rological Office, in its remarks prepared for publication in the next morning's newspapers, reasoning on the telegraphic reports made on the 15th at 6 p.m., said: "The high pressure area over England and the North Sea is moving eastwards, and new low pressure systems seem to be advancing from the westward." At this time the central area of the approaching storm system was about 500 miles to the south-west of Valencia.

At 8 a.m. on the 16th the barometer at Valencia had fallen to 29·42 ins., which was a fall of 0·48 in. since the previous day; and the North-easterly wind which had been blowing over the British Islands had given way entirely to a warm and humid South-westerly current of air, under the influence of the large disturbance which was rapidly approaching our shores from the westward. The telegraphic reports received by the Meteorological Office did not show a stronger force than a moderate gale (7 of Beaufort's Notation), and that force was only attained at Valencia, Roche's Point, and Scilly. The gradient for Southerly winds at 8 a.m. was 0·6 in. in 460 miles.

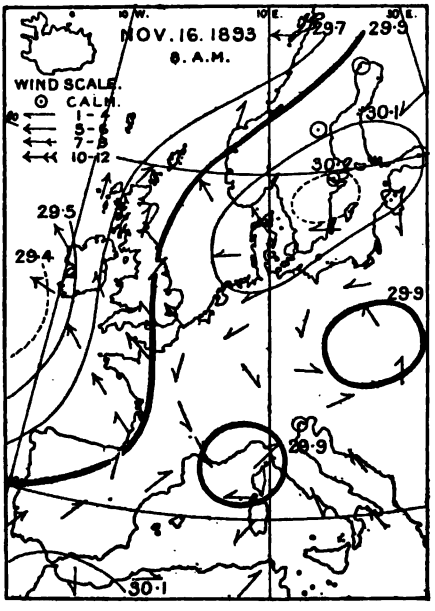

FIG. 1.

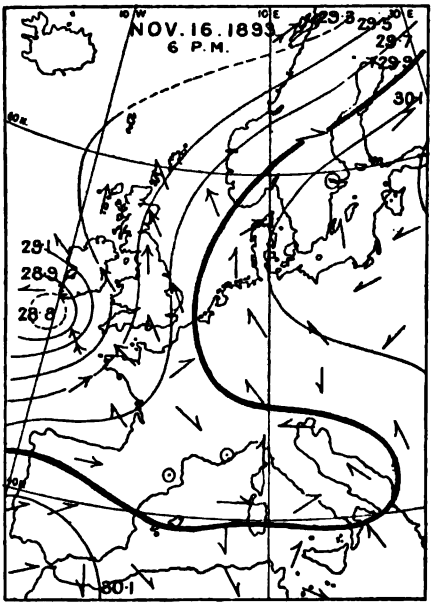

FIG. 2.

At noon the Barque *Ariel*—Captain U. S. Goldsmith—keeping a log for the Meteorological Office, was near the centre of the disturbance. The lowest reading of the barometer occurred at this time, and the wind is reported as calm. The vessel at noon was about 300 miles west of Valencia, and the captain afterwards reported a heavy North-westerly gale lasting about 8 days.

The 2 p.m. reports showed that a strong gale was blowing at Scilly, and a fresh gale at Valencia from South-east, while the barometric fall had extended over the whole Kingdom.

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At 6 p.m. the central area of the storm was within a few miles of our extreme south-west coasts, and in the south of Ireland the barometer had fallen to 28·8 ins.; while on our south-east coasts it was nearly an inch higher. The gradients for South and South-west winds had therefore considerably increased since the morning, and gales or strong winds were now blowing over the whole of the British Islands.

The lowest barometer occurred at Valencia at 7 p.m. on the 16th, and the wind shifted from East by south to West-south-west between 8 and 9 p.m.

At 8 a.m. on the 17th the central area of the storm was situated over the west of Scotland, the lowest barometer reading being 28·53 ins. at Ardrossan. The storm had traversed Ireland at the rate of about 24 geographical miles per hour, passing from south-west to north-east during the preceding night; and the winds at all the Irish stations had shifted to the North-westward and had generally moderated in force. During the night and early morning a heavy gale was experienced over Ireland and in the north of Scotland, as well as at many places in England. The greatest difference of barometer readings in a given distance was now in the rear of the storm, where a rapid recovery had set in.

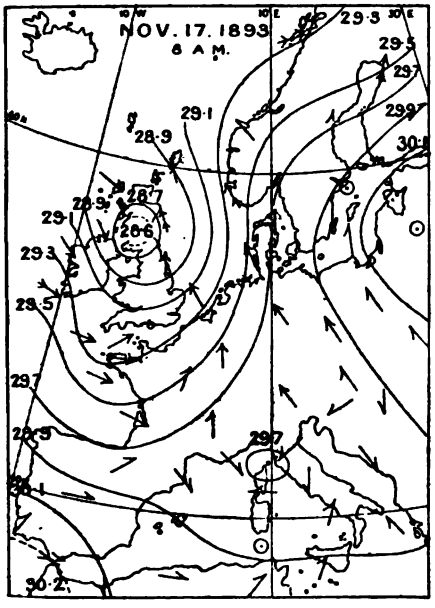

FIG. 3.

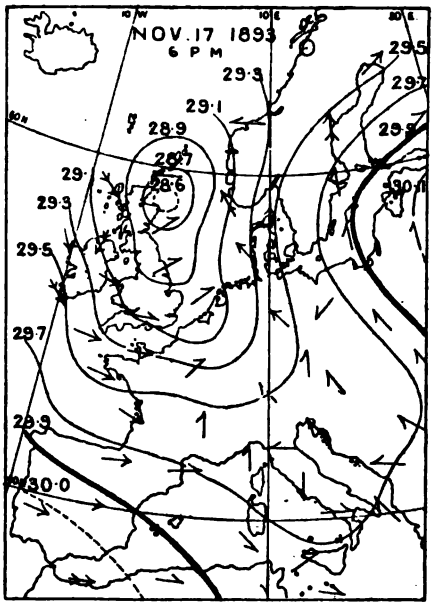

FIG. 4.

At 2 p.m. the centre had traversed Scotland, and was situated close to the eastward of Peterhead. The anemometrical records at Aberdeen show a shift of wind from South by east to West by north between 1 and 2 p.m.

The winds had become North-westerly over the greater part of England, while the steepest gradients were in the south-western segment of the storm area and for decidedly North-westerly gales.

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The 6 p.m. observations showed that the central area of the storm was close to the eastward of Wick, where the barometer was 28·57 ins., and a moderate gale was blowing from the North. The gradients for North-westerly winds were still very steep, the difference of the barometer from Wick to Valencia amounting to an inch. The North-westerly gale was very strong, but winds had lulled considerably over the eastern portion of the Kingdom, where subsidiary disturbances were very prevalent. The north-westerly gradient extended from Wick to the south of Spain.

The anemograms at Deerness, Orkney, show that at 6 p.m. the wind shifted from East by north to North by east, and the velocity increased very suddenly.

At 8 a.m. on the 18th the storm system had taken a very sudden and abrupt change in its path, and was now travelling south-eastwards, skirting

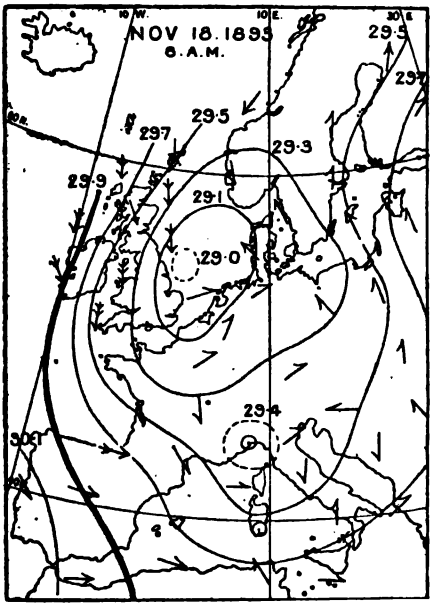

FIG. 5.

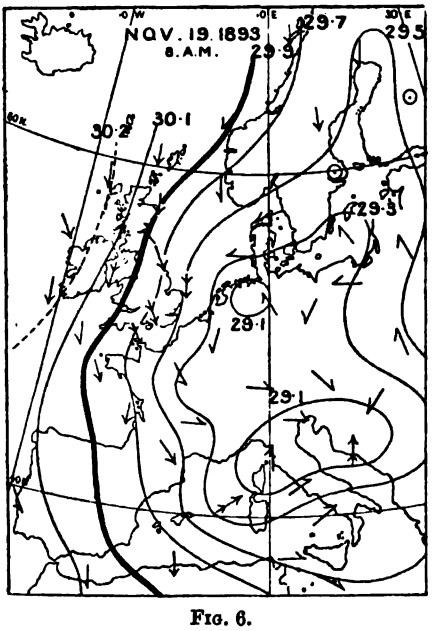

FIG. 6.

close to our east coasts. The centre was situated in the North Sea about 50 miles to the east of Scarborough, but the disturbance was gradually filling up, the lowest barometer reading being 28·99 ins. at Spurn Head. The gradients for Northerly winds were the steepest, the difference of barometer reading amounting to an inch between York and Valencia. Gales occurred in the preceding night over nearly the entire Kingdom, and were exceptionally severe over Scotland and very heavy over Ireland.

The self-registering records at Aberdeen indicate that the centre of the storm area repassed that station on a south-easterly track between 9 and 10 p.m. on the 17th. It passed Alnwick Castle about 1 a.m. on the 18th.

At 2 p.m. the central area of the disturbance was still situated off the south-

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east coast of England, the lowest barometer reading being 29·08 ins. at Yarmouth. Gradients were steep over the entire Kingdom for Northerly winds, and gales were blowing over nearly the whole of the British Islands. The barometer was now rising in all parts of the country.

The 6 p.m. observations showed that the centre was continuing its passage to the south-south-east, and was now situated over Belgium. Strong Northerly gales were still prevalent over the United Kingdom, and the wind had increased in force over the south-east of England. The difference of barometer readings between Valencia and the coast of Kent was rather more than an inch.

At 8 a.m. on the 19th the disturbance had again taken rather a different course, and was travelling east-south-eastward; the centre lay now close to Cuxhaven, where the barometer was reading 29·10 ins.

Northerly gales continued to blow on most of our coasts, but the gradients were becoming less steep over the western portion of the Kingdom; they were, however, still steep over the south-east of England, and were accompanied by strong Northerly gales.

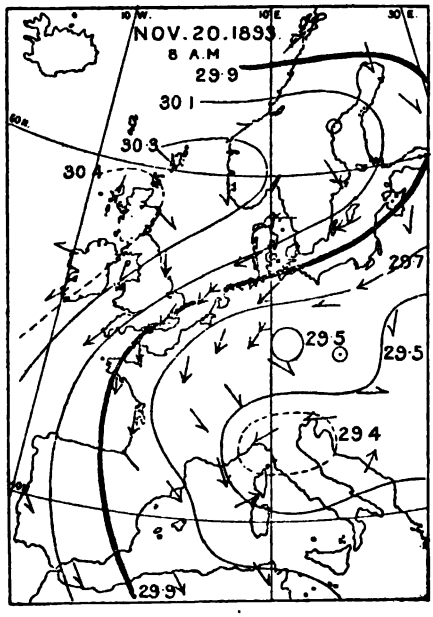

FIG. 7.

On the 20th the gradients were steep for Northerly winds, but the gales were generally subsiding, although still blowing strongly on our south-east coasts, and at Yarmouth the highest wind velocity throughout the gale was attained at 5 a.m.

The anemograph records, kindly supplied by the Meteorological Council, have been tabulated for a period of 4½ days, and are given for 16 different stations over the United Kingdom in Table I. They show that the hourly

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TABLE I.—WIND VELOCITY IN MILES PER HOUR, NOVEMBER 16TH–20TH, 1893.

Hour.	Valencia.	Dublin.	Armagh.	Orkney.	Aberdeen.	Glasgow.	Alnwick Castle.	North Shields.	Fleetwood.	Liverpool.	Holyhead.	Yarmouth.	Greenwich.	Kew.	Falmouth.	Scilly.
16th.																
10 a.m.	33	16	26	23	17	10	17	26	21	18	32	31	10	15	30	46
11 ,,	39	14	21	25	20	11	20	24	21	22	25	30	14	18	30	51
Noon	46	12	23	29	22	12	21	23	23	27	31	29	12	20	30	53
1 p.m.	44	13	27	26	23	11	15	24	32	29	36	29	17	15	30	55
2 ,,	46	14	24	29	24	9	21	25	33	35	34	32	13	19	35	51
3 ,,	40	22	26	28	24	16	18	27	31	32	26	37	13	17	37	48
4 ,,	36	21	24	31	27	15	25	33	29	37	25	36	10	11	40	47
5 ,,	26	23	24	30	29	13	23	34	39	39	25	41	7	15	36	47
6 ,,	9	18	23	38	26	9	37	31	38	42	34	43	10	19	38	42
7 ,,	3	24	16	39	30	14	30	33	39	47	46	42	16	19	37	40
8 ,,	6	28	15	36	29	17	30	36	43	42	51	39	14	23	37	36
9 ,,	17	24	17	35	24	19	36	35	44	44	54	43	16	21	38	34
10 ,,	33	19	18	35	29	19	28	34	40	44	64	43	17	19	38	31
11 ,,	40	11	20	35	28	13	37	34	49	41	60	45	14	22	38	32
Midnt.	37	10	20	34	28	18	34	31	52	44	61	41	15	20	33	32
17th.																
1 a.m.	38	18	13	35	26	12	33	32	54	33	60	45	20	23	36	
2 ,,	30	15	10	34	32	15	27	34	50	35	58	44	15	21	30	
3 ,,	31	17	7	33	27	19	40	40	47	34	60	41	17	17	30	
4 ,,	28	21	11	36	34	17	29	39	41	28	38	33	16	22	28	
5 ,,	35	17	12	40	31	18	35	36	44	23	43	36	16	21	27	
6 ,,	45	18	14	41	32	15	32	37	37	27	31	33	17	20	29	
7 ,,	52	17	14	36	39	7	32	40	40	28	39	30	17	23	29	
8 ,,	50	16	15	34	35	8	37	43	40	30	28	30	22	19	29	
9 ,,	52	19	19	30	34	10	23	47	42	26	32	24	19	20	29	
10 ,,	49	18	19	26	29	20	32	41	39	30	32	24	17	19	26	
11 ,,	44	17	16	23	29	24	26	44	36	37	40	22	18	22	27	
Noon	49	17	15	27	24	27	34	32	38	35	40	17	22	23	45	
1 p.m.	48	19	15	23	8	25	44	35	44	33	41	16	22	23	44	Clock stopped.
2 ,,	45	18	17	20	26	14	43	29	39	32	32	16	21	24	40	
3 ,,	50	14	16	15	22	18	41	25	35	35	29	12	22	24	34	
4 ,,	50	20	17	13	17	21	28	25	31	34	31	11	22	20	29	
5 ,,	50	18	14	14	14	14	26	24	31	25	30	14	14	18	27	
6 ,,	52	22	16	46	12	11	16	17	24	26	28	17	19	28	23	37
7 ,,	53	19	18	81	11	9	15	18	18	17	48	14	31	19	22	34
8 ,,	45	19	23	86	16	10	7	8	9	10	52	15	29	15	26	48
9 ,,	41	21	23	96	21	21	5	5	14	12	58	25	20	14	37	51
10 ,,	51	20	29	95	29	30	6	6	14	7	61	23	19	14	44	53
11 ,,	53	23	24	93	39	39	12	10	25	5	59	22	20	14	42	55
Midnt.	57	21	27	91	44	37	15	9	24	12	68	16	18	16	35	58
18th.																
1 a.m.	52	24	24	90	46	41	25	15	28	13	70	14	15	16	44	60
2 ,,	54	23	26	86	45	33	22	26	31	26	81	11	16	16	48	66
3 ,,	58	21	27	82	39	44	30	31	42	24	85	8	15	19	46	65
4 ,,	60	21	30	80	42	43	30	32	40	28	78	8	14	9	44	61
5 ,,	54	21	31	76	44	31	28	32	50	27	80	9	10	4	45	61
6 ,,	54	28	28	74	41	35	30	37	52	30	80	9	8	4	49	66
7 ,,	52	24	30	70	40	32	36	51	53	40	81	6	8	5	49	63
8 ,,	41	31	25	65	41	28	36	67	63	49	84	6	7	7	50	59
9 ,,	48	33	27	64	37	33	39	69	83	49	88	6	8	8	53	60
10 ,,	45	31	25	65	40	27	30	69	87	44	87	4	10	11	55	59
11 ,,	40	35	20	59	38	38	38	68	79	49	89	4	9	16	54	53
Noon	50	32	21	59	36	29	35	64	80	45	79	3	8	13	53	58
1 p.m.	52	35	23	59	34	29	26	64	82	46	80	10	14	15	52	57
2 ,,	42	29	15	54	30	33	34	59	70	42	84	8	15	18	52	54
3 ,,	43	20	15	53	33	29	26	63	77	41	79	5	18	24	53	51
4 ,,	43	10	15	54	31	27	26	58	71	43	71	3	24	26	50	50
5 ,,	42	14	17	55	27	14	29	51	70	42	74	6	26	30	51	51

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TABLE I.—Wind Velocity in Miles per Hour, November 16th–20th, 1893.
Continued.

Hour.	Valencia.	Dublin.	Armagh.	Orkney.	Aberdeen.	Glasgow.	Alnwick Castle.	North Shields.	Fleetwood.	Liverpool.	Holyhead.	Yarmouth.	Greenwich.	Kew.	Falmouth.	Scilly.
18th.																
6 p.m.	44	13	15	56	29	17	29	48	64	44	70	8	35	31	39	55
7 „	51	13	12	51	29	14	22	43	70	43	64	23	33	38	47	57
8 „	39	7	15	55	29	15	27	43	69	39	66	48	35	32	31	52
9 „	39	4	10	59	25	11	23	38	65	40	59	42	34	34	36	58
10 „	39	9	14	52	27	11	24	38	62	38	65	40	32	32	26	55
11 „	42	9	17	54	29	17	23	35	60	36	62	36	29	29	28	49
Midnt.	44	10	15	54	29	18	25	37	55	34	68	41	31	31	26	47
19th.																
1 a.m.	38	7	14	55	26	23	21	36	62	35	68	48	33	30	25	46
2 „	43	8	11	51	24	16	23	35	55	38	63	44	33	31	24	46
3 „	39	7	9	56	22	15	25	36	48	33	67	43	33	33	25	47
4 „	33	9	9	53	29	20	23	34	55	35	60	39	33	33	25	44
5 „	32	13	9	49	25	17	20	31	56	36	65	45	33	30	26	46
6 „	33	11	11	47	24	20	21	38	52	34	60	35	33	33	28	43
7 „	32	7	11	51	26	17	21	38	54	34	69	33	26	31	26	42
8 „	35	5	11	48	26	13	24	47	53	39	65	37	31	30	23	41
9 „	32	6	9	47	30	14	21	45	61	39	66	36	30	31	27	43
10 „	33	8	10	44	29	11	22	44	58	35	65	34	29	31	29	36
11 „	22	10	10	37	25	13	26	44	56	35	68	43	31	34	34	40
Noon	25	15	13	39	20	17	21	48	51	32	67	36	34	32	29	38
1 p.m.	19	16	14	39	19	19	26	40	47	34	60	26	32	29	29	37
2 „	19	15	13	33	17	16	25	44	57	36	64	20	28	27	27	36
3 „	17	16	11	29	19	18	21	41	53	36	58	29	27	28	28	40
4 „	20	13	10	31	17	21	19	36	42	34	58	26	24	25	22	36
5 „	18	11	9	31	18	13	26	32	56	33	62	38	20	17	18	34
6 „	23	11	7	31	17	15	28	28	58	31	56	45	19	23	24	33
7 „	25	10	6	25	18	17	21	29	44	31	52	42	22	23	29	33
8 „	18	12	6	24	15	11	22	26	42	30	57	45	29	27	29	34
9 „	24	15	7	22	16	15	25	25	50	25	55	50	28	33	27	35
10 „	35	14	10	20	17	12	27	28	47	19	51	50	31	33	25	33
11 „	27	11	8	20	13	16	22	22	41	21	51	46	30	31	30	33
Midnt.	18	11	7	16	14	11	17	22	39	22	50	53	33	29	27	32
20th.																
1 a.m.	11	11	8	16	16	10	20	23	43	18	53	52	28	28	19	31
2 „	9	12	8	13	13	9	23	24	41	23	55	54	30	29	21	29
3 „	9	13	7	13	11	9	16	19	35	17	51	58	30	30	20	27
4 „	4	12	7	13	15	12	18	22	37	16	50	60	30	30	20	25
5 „	7	12	6	17	15	13	20	25	38	20	50	64	32	30	17	23
6 „	8	15	6	15	11	10	20	24	35	17	48	63	30	28	15	22
7 „	11	11	5	10	12	14	23	26	36	18	48	57	29	29	16	22
8 „	12	10	6	10	12	14	17	21	35	21	45	60	25	28	19	21
9 „	15	9	5	9	11	11	25	25	36	19	48	62	29	31	17	22
10 „	12	10	7	7	11	11	29	24	28	22	47	56	32	29	19	21
11 „	15	11	9	6	11	13	32	20	28	18	45	57	32	33	23	24
Noon	16	13	11	8	11	11	25	28	25	20	49	57	32	30	24	22
1 p.m.	17	12	10	5	8	15	32	31	27	22	49	58	32	31	23	22
2 „	22	12	11	7	11	15	27	29	23	23	42	57	35	25	24	22
3 „	18	13	10	8	11	13	21	24	25	27	33	57	33	29	21	22
4 „	11	14	10	7	11	12	22	22	17	27	40	53	29	26	20	22
5 „	12	12	7	7	11	8	22	23	11	20	35	49	30	28	17	23
6 „	11	15	5	6	10	7	15	20	13	19	32	49	28	26	13	26
7 „	16	12	6	12	11	7	14	19	16	20	33	48	25	26	13	20
8 „	15	14	8	11	13	7	10	17	20	17	30	44	25	23	14	22
9 „	15	11	6	12	12	6	15	17	17	21	30	46	29	22	14	20

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velocity of the wind was 45 miles, or above it, in some part of the British Islands almost continuously for 4½ days. In this Table, and throughout this paper, the factor 8 has been retained, as no systematic change has yet been introduced into the anemometrical records either in this country or abroad. The anemometers used are not all of the pattern known as the large Robinson, but quite irrespective of the difference this would occasion there are wide differences which cannot satisfactorily be explained. For instance, at stations so close together as Holyhead and Liverpool, the average hourly velocities for the 4½ days are respectively 54 miles and 30 miles. On the other hand, it will be seen that the average hourly velocity during the whole period of the gale was identical at Greenwich and Kew, being 23 miles at both observatories.

The absolutely highest hourly velocity in Table I. is 96 miles, recorded at Deerness in the Orkneys at 9 p.m. on the 17th. The hourly velocity at Orkney was 90 miles or above for five consecutive hours, and the observer, Mr. Spence, says "the hurricane commenced exactly at 6 p.m. on the 17th, like the shot of a gun." It will be seen from Table I. that at 5 p.m. the hourly velocity was 14 miles, at 6 p.m. it was 46 miles, and at 7 p.m. it had increased to 81 miles.

There are only five previous instances in 30 years, since 1863, of the wind attaining 80 miles and upwards in the Orkneys; these instances are all given in Table III. (p. 51). The absolutely highest velocity previously observed in Orkneys was 88 miles an hour.

Table II. gives a few of the principal details from Table I. grouped together for the purpose of comparison. From the column showing the maximum velocity it will be seen that the greatest violence of the wind on shore occurred at Orkney, Holyhead, and Fleetwood. The gale was of longest duration at Holyhead, the wind attaining the hourly velocity of 45 miles (force 8 of Beaufort's Notation) or upwards, for 76 hours, while it was 65 miles (force 10) for 31 hours, and for 4 hours it was 85 miles or upwards (force 12).

Table III. gives the dates of severe gales from 1869 to 1893, a period of 25 years, on which the wind velocity was 80 miles an hour and upwards, as registered by the anemometers erected by the Meteorological Office.

The above records in all show 21 gales in which the hourly velocity of the wind has attained 80 miles which have occurred in the British Islands during the last quarter of a century.

The following are notes of squalls recorded by anemometers during the gale on November 18th:—

Deerness.—There is evidence of strong squalls, but owing to the general steepness of the lines it is difficult to separate individual squalls. From 9.55 p.m. to 10.25 p.m. 50 miles were registered = 100 miles per hour. Just before midnight the trace over some minutes gives a rate of considerably over 100 miles per hour.

Fleetwood.—About 10 a.m., for half-an-hour, a rate of nearly 100 miles per hour was attained. Near noon, in severe squalls, a rate of quite 120 miles per hour is shown.

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TABLE II.—FORCE OF WIND INDICATED BY VELOCITY ANEMOMETERS, NOVEMBER 16TH, 10 A.M., TO 20TH, 9 P.M.

Station.	Maximum Velocity.			Hours with Velocity			Mean Hourly Velocity for 4½ days.
	Miles.	Direction.	Date.	45 Miles and above.	65 Miles and above.	85 Miles and above.	
Valencia	60	NNW	18 4 a.m.	31	..	..	33
Dublin	35	N	18 11 a.m., 1 p.m.	..	..	..	16
Armagh	31	N	18 5 a.m.	..	..	..	15
Orkney	96	N	17 9 p.m.	40	15	7	39
Aberdeen	46	NW b N	18 1 a.m.	2	..	..	24
Glasgow	44	N b E	18 3 a.m.	..	..	..	18
Alnwick Castle	44	SW b S	17 1 p.m.	..	..	..	25
North Shields	69	N	18 9 a.m., 10 a.m.	16	4	..	33
Fleetwood	87	N	18 10 a.m.	44	12	1	43
Liverpool	49	NW, N	18 8 a.m., 9 a.m., 11 a.m.	6	..	..	30
Holyhead	89	N b W	18 11 a.m.	76	31	4	54
Yarmouth	64	NE b N	20 5 a.m.	31	..	..	33
Greenwich	35	NNW, NNE	18 6 p.m., 8 p.m.; 20 2 p.m.	..	..	..	23
Kew	38	NNW	18 7 p.m.	..	..	..	23
Falmouth	55	NNW	18 10 a.m.	17	..	..	31
Scilly	66	NW, NW b N	18 2 a.m., 6 a.m.	41	3	..	41

TABLE III.—DATES OF GALES FROM 1869 TO 1893, WITH WIND VELOCITY 80 MILES AN HOUR AND UPWARDS.

Station.	Date and Hour of Maximum Velocity.	Direction of Wind.	Maximum Hourly Velocity.
Sandwick	1869. Feb. 27, 4 a.m.	NW by W	81
Valencia	1871. Jan. 15, 11 p.m.	SSW	81
Holyhead	1872. Nov. 23, 7 p.m.	SSE	80
,,	1877. Feb. 20, 3 a.m.; ,, ,, 4 a.m.	NW, NW by N	82
Sandwick	1877. Nov. 16, 3 a.m.	W	83
Yarmouth	1881. Jan. 18, 11 a.m.	E	80
Valencia	1881. Nov. 21, 10 p.m.	SW	82
Sandwick	1882. Jan. 6, 5 p.m.	W	82
,,	1884. Jan. 20, 9 a.m.	W by S	88
,,	1885. Feb. 21, Midt.	S by E	82
Valencia	1885. Dec. 3, 9 p.m.	S by W	82
Fleetwood	1886. Dec. 9, 9 a.m.	NW by W	80
,,	1887. May 20, 8 a.m.	NW	91
Holyhead	1887. Nov. 1, 11 a.m.	SE	80
Alnwick Castle	1888. Nov. 16, 11 a.m.	SW	80
Fleetwood	1889. Feb. 8, 8 p.m.	NW	86
,,	1889. Oct. 7, 11 a.m.	W by N	85
,,	1890. Oct. 16, 5 p.m.	NW	82
,,	1890. Nov. 7, 9 a.m.	NNW	87
,,	1891. Dec. 11, 1 a.m.	NW	90
Orkney	1893. Nov. 17, 9 p.m.	N	96
Fleetwood	1893. Nov. 18, 10 a.m.	N	87
Holyhead	1893. Nov. 18, 11 a.m.	N by W	89

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Holyhead.—The trace is unsatisfactory for observation of squalls, but the required information is supplied by the "bridled" anemometer.

Scilly.—There are no indications of squalls of exceptional strength, but the anemometer here is of smaller size, and the trace is also smaller in width.

Dublin.—Nothing worthy of special remark.

Falmouth.—Nothing remarkable.

Valencia.—Squalls are shown on the trace, but they are not very marked.

Armagh.—Nothing calling for special note.

Aberdeen.—Some well-marked squalls, one at 3.45 a.m. 18th, quite 80 miles per hour.

Kew.—Trace indicates a very squally wind; there are some very distinct squalls shown, but the shortest reliable piece of line does not give more than 55 miles per hour.

The "bridled" anemometer at Holyhead, which is essentially suitable for the registration of gusts, gives several instances of gusts at the rate of 115 miles an hour, using the old factor 3. Gusts of this force were of considerable frequency on the 18th from 6.30 a.m. to 11 a.m., and indeed until 8 p.m. the violence of the gusts was but very little less.

Mr. Dines' "tube" anemometer, which is in work at the Meteorological Office in Victoria Street, Westminster, gave the maximum velocity of the squalls as 78 miles an hour on the 18th between 5 and 6 p.m., the factor 3 again being used.

There were many squalls of considerable interest during the gale, and in some instances they can be traced for a considerable distance over the country. The scope of this paper will not admit of any especial attention being given to these, although it is the squalls in such gales that are of the highest importance, and it is these which probably occasion the largest amount of damage and which render the storm so destructive. One squall which passed over the Metropolis, and was traceable for some distance on its outskirts, took place on the 17th between 5 and 6 p.m., fully 24 hours before the greatest violence of the gale occurred. Mr. Ellis has sent me tracings of the self registering instruments at Greenwich which show this squall to have passed over the Royal Observatory at 5.48 p.m. on the 17th—it is very clearly shown in all the records of the self-registering instruments. At Kew it is equally well marked, and occurred at 5.20 p.m., while Mr. Mawley's anemograms show that it occurred at Berkhamsted at 5 p.m. The same characteristic is shown by two interesting barograms lent by Mr. L. P. Casella, the squall passing over Holborn at about 6 p.m.

It is not possible to give in detail an exact statement of the changes shown by the anemograms, but the following brief summaries may be of interest as supplementing the hourly velocities given in Table I.

Valencia.—There was a decided lull in the wind during the evening of the 16th, and at 7 p.m. the velocity was only 3 miles an hour, the direction at the time being East by south; there was a sudden shift to West-south-west at 9 p.m., after which the wind decidedly increased. The wind afterwards shifted steadily through West to North, where it remained during nearly the whole of the 17th, 18th, and 19th. The maximum force of 60 miles in the hour, which occurred at 4 a.m. on the 18th, was from North-north-west.

Dublin.—The wind hauled steadily from South-east through South and West

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to North, where it remained for about 3 days. The strongest wind was from due North.

Armagh.—The wind changed from East through South and West to North, the change being greatest in the early morning hours of the 17th, the direction was East-south-east at 1 a.m. and West at 4 a.m. It remained fairly steady at North for fully 3 days. The maximum force was from North.

Orkney.—The direction was steady at South during the after part of the 16th. On the 17th it drew gradually Easterly, and at 5 p.m. was East by north, the velocity being 7 miles an hour. At 6 p.m. it shifted to North by east, and the velocity had increased to 46 miles an hour; at 7 p.m. it had increased to 81 miles, the direction being North, and it afterwards remained steady at North for nearly three days. The direction from 7 p.m. on the 17th to 4 a.m. on the 19th never varied more than 1 point from North.

Aberdeen.—The direction of wind was steady at South-east till 1 p.m. on the 17th, when it suddenly shifted to West, and during the remainder of the day was unsteady between South-west and North-west. The maximum force was from North-west by north at 1 a.m. on the 18th, and it was afterwards very steady at North for more than 2 days.

Glasgow.—The direction was fairly steady at East till 7 a.m. on the 17th, shifted to South at 9 a.m., West-south-west at 10 a.m., and afterwards through West to North, where it remained steady for nearly 3 days.

Alnwick Castle.—The direction was South-west till 10 a.m. on the 17th, after which it shifted gradually through South and West to North. The maximum force was from South-west by south at 1 p.m. on the 17th.

North Shields.—The wind shifted gradually from South-east through South and West to North, from which latter point the maximum velocity was reached. The direction was steady at North for about 2 days.

Fleetwood.—The wind was fairly steady at South-east throughout the 16th, and on the 17th until 5 a.m., after which it shifted through South and West to North. The maximum velocity was from North at 10 a.m. on the 18th, and the direction remained steady at North throughout the 18th and 19th.

Liverpool.—The direction was South-east throughout the 16th, and was unsteady between South-east, South, and West-north-west on the 17th. It shifted to North-north-west at 1 a.m. on the 18th, and remained within a point or two of North during the next 2 or 3 days. The highest velocity of wind was from North-west.

Holyhead.—The wind was at first South-easterly, and shifted through South and West to North. The direction was steady at North throughout the 18th, 19th, and part of the 20th. The maximum velocity of 89 miles was from North by west at 11 a.m. on the 18th.

Yarmouth.—The direction of the wind was Easterly and South-easterly throughout the 16th, and shifted gradually through South to West by the evening of the 17th, and remained between West and South-west until 6 p.m. on the 18th, after which it shifted suddenly to North, near which point it continued for some time. The maximum velocity was 64 miles an hour from North-east by north at 5 a.m. on the 20th.

Kew.—The direction was chiefly East and South-east during the 16th, and was unsteady between South and West on the 17th. It shifted to North-north-west at mid-day on the 18th, and remained between North-north-west and North-north-east to the close of the 20th. The maximum force was from North-north-west at 7 p.m. on the 18th.

Falmouth.—The direction was between South-east and South-west on the 16th, and between South-west and North-west on the 17th. It shifted to North about mid-day on the 18th, where it remained during the next 2 or 3 days, the direction during this time only varying a point or two on each side of North. The maximum velocity was from North-north-west at 10 a.m. on the 18th.

Scilly.—The wind shifted from South-east through South and West to North, where it remained fairly steady for 2 or 3 days. The maximum velocity occurred at 2 a.m. and 6 a.m., 18th, the respective directions being North-west and North-west by north.

Through the courtesy of the Board of Trade, I have been allowed access to the

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official returns which give the casualties to vessels involving either loss of life or saving of life by some extraneous means. The data are accurate and complete, and deal merely with the storm from November 16th to 20th. The total loss of life reported to the Board of Trade within the limits of the *Wreck Chart*, and of four weeks after the date of the storm, on December 15th, was 385 lives from all vessels Foreign and English. The returns are made for our coasts and for a very limited area of the sea adjacent to our coasts, the limitation being that common to the ordinary *Wreck Charts* published annually by the Board of Trade.

The several casualties have been grouped for the respective days of the storm with the following result:—

Nov. 16	Lives Lost	10[1]	Lives Saved	22
,, 17	,,	47	,,	65
,, 18	,,	174	,,	330
,, 19	,,	51	,,	94
,, 20	,,	39	,,	89
Total	,,	321	,,	600

Vessels abandoned, foundered, stranded, &c., in every case involving either loss of life or saving of life by some means other than the vessel experiencing casualty:—

Nov. 16	Number of Vessels Lost	7[2]
,, 17	,,	,,	22
,, 18	,,	,,	71
,, 19	,,	,,	25
,, 20	,,	,,	15
Total	,,	,,	140

The Board of Trade returns, from which the above facts are obtained, do not deal with loss of life, &c., in vessels on the open ocean.

In addition to the above, there were on December 16th—four weeks after the storm—21 vessels, many of which are large steamers, posted on the "Overdue" List in the *Liverpool Journal of Commerce*—most of these being probably involved in the storm.

Both the time and position of the casualty are given in the Board of Trade returns, and I made an attempt at producing a Wreck Chart for this particular storm, but in many cases the casualties are too close and too numerous to be pictured on anything like a reasonable sized chart, consequently the losses cannot be shown graphically, and I have considered the lists to be rather too much in detail for the scope and limits of this paper.

There is, however, one special feature. The losses were, for—

Nov. 16	principally on our	west	coasts.
,, 17	,, ,,	north	,,
,, 18	spread over all		,,
,, 19 and 20	chiefly ,,	east	,,

[1] These scarcely belong to 16th.
[2] 2 vessels scarcely belong to 16th.

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The National Lifeboat Institution state "that during the recent great gale, lasting from November 17th to 21st inclusive, our lifeboats were launched on service 82 times, and saved 208 lives and 6 vessels. The crews of 22 other life-boats were also assembled in readiness for launching, but their services were not required."

The Secretary of Lloyd's, Col. Hozier, in forwarding a list of casualties, says: "On November 20th we had, I believe, what was our heaviest Loss Book; in that day 144 casualties were posted on it."

For the following statement, which shows the vast destruction of timber in the northern portion of the Kingdom, I am indebted, through the kind courtesy of His Grace the Duke of Sutherland, to Mr. Henry Wright, of the Sutherland Estates Office.

Tongue District of Sutherland. North-west.—The storm began about 3 p.m on the 17th, a point or two West of North; it soon got into true North and remained there for most of the night; later it got round a few points to the Eastward. About 1800 trees were blown down, namely, 819 fir, 417 larch, 147 spruce, 115 birch, 106 beech, the remainder ash, oak, elm, and various. There is much damage to roofs of houses, &c.

Dunrobin District of Sutherland. East side.—Never within living memory had such a storm been experienced on the east coast of the county. The wind was accompanied by heavy rain. It was worst from 8 o'clock till midnight. In the morning (18th) with snow and frost. The estimated number of trees blown down is 52,000, or say, at most, 55,000.

By the aid of the *Pilot Chart of the North Atlantic Ocean* for December, published by the Hydrographic Office of the United States Navy Department, coupled with information obtained from an examination of the logs of vessels which experienced the storm, the storm can be tracked completely across the Atlantic.

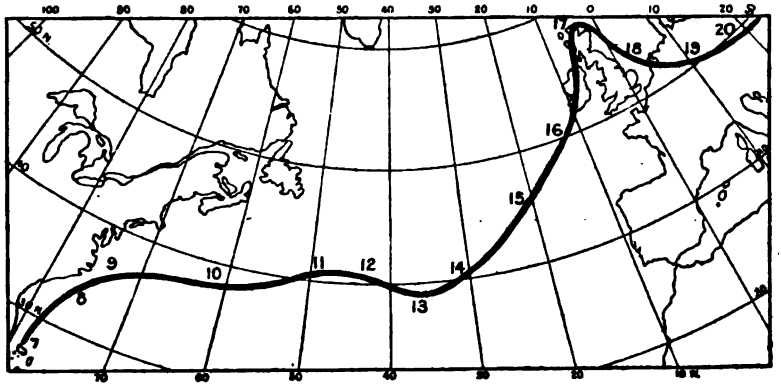

FIG. 8.

The *Pilot Chart* says:—

"On November 7th a depression originated east of the Florida coast near the Bahamas. At the same time an area of high pressure prevailed over the New England and middle Atlantic States. By noon, G. M. T., of the 8th, the depression had moved up the Gulf Stream almost to Cape Hatteras. The area of high pressure in the meantime moved eastward off the New England coast. On the 9th the storm was central just to the northward and close to Cape Hatteras,

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Vessels along the coast on the 8th and 9th reported the wind of force 10-11. From Hatteras the storm moved to the northward of east and crossed the Atlantic, as shown graphically on the chart. From reports received, this storm maintained its energy during the entire passage."

I am indebted to the kindness of the Cunard Steamship Company for the log of the ss. *Lucania*, bound from New York to Liverpool. This vessel left New York on November 11th, and from the very time of starting she was under the influence of this storm system, and throughout her passage she experienced North-easterly and Northerly winds, being on the northern side of the storm system until her arrival off the English coasts.

On the 12th, the wind increased to a strong gale with a rapidly falling barometer—ship at noon in lat. 41°28′ N., long. 62°40′ W.

On the 13th a strong North-easterly gale was blowing all day with a high sea, barometer falling slightly—ship at noon in lat. 43°48′ N., long. 54°57′ W.

On the 14th the vessel had gained considerably on the storm system, and during the afternoon she was at her nearest position to the central area of the disturbance, the barometer being as low as 29 ins. A fresh North-easterly gale was experienced during the greater part of the day, the vessel at noon being in lat. 46°6′ N. and long. 46°20′ W.

On the 15th the vessel at noon was in lat. 49°11′ N., long. 38°5′ W., and she again experienced a North-easterly gale throughout the day with a uniformly low barometer.

On the 16th the storm was somewhat outstripping the *Lucania*, travelling more quickly to the eastward, and the vessel experienced a steadily rising barometer, although a fresh to strong North-north-easterly gale was blowing throughout the day. The vessel's position at noon was lat. 50°34′ N., long. 27°0′ W.

On the 17th the vessel was again gaining on the storm, and in consequence she experienced a falling barometer. The wind was between North-north-east and North-north-west, with its force ranging between a moderate and a hard gale. Ship at noon in lat. 51°23′ N., long. 15°30′ W.

On the 18th the vessel experienced a hurricane with terrific squalls—direction steady at North throughout the day. The barometer was rising as the disturbance was again moving Eastwards, and the high barometer in the rear was decidedly asserting itself. Vessel at noon in lat. 52°12′ N., long. 6°2′ W., and before midnight the ship was off the Great Orme's Head.

Owing to the violence of the gale the vessel was 25 hours doing the passage from Roche's Point to the Mersey, while on the outward passage she had covered that distance under 12 hours.

The storm was accompanied by heavy falls of snow, sleet, and rain in many parts of the British Islands, and the gale was exceptionally violent on the French coasts, but the object of the paper is primarily to deal with its effect and influence over the British Islands, and my endeavour has been, as far as possible, to bring the scope of the paper within a limited compass.

In conclusion, I have to thank the Meteorological Council for having so kindly placed the whole of the material in the Meteorological Office at my disposal for the preparation of this paper, and I would acknowledge the great assistance given to me by many Fellows of the Society and others who have so readily communicated their observations.

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DISCUSSION.

THE PRESIDENT (Dr. C. Theodore Williams) said that Mr. Harding's communication was full of interesting information. Concerning the reference which had been made to the destruction of trees on the Duke of Sutherland's property, he (Dr. Williams) had heard that on another Scottish estate, that belonging to Lord Strathmore, it was estimated that 100,000 trees, chiefly firs, were blown down. A peculiar feature in the destruction wrought was that the fallen trees were distributed in circular groups.

Mr. F. J. BRODIE said that an interesting feature in the history of the storm was the complete reversal that took place during its progress in the distribution of pressure over Western Europe. At the time the depression first advanced from the Atlantic the barometric readings were highest over Sweden and Denmark, but on November 17th, when the centre moved north-eastwards across Ireland and Scotland, the high pressure system receded eastwards to Russia. It was now evident that in the rear of the disturbance a large anticyclone was advancing over the Atlantic, and on the night of the 17th, when this system reached our western coasts, the storm centre changed its course and moved in a south-south-easterly direction over the North Sea. The alteration in the course of the storm, though quite unexpected at the time, was fully explained in the light of subsequent events, and both in the earlier and later stages of its progress the depression obeyed the well-known law in accordance with which such systems ordinarily move along to the left of the high pressure area existing at the time. Another feature in connection with the movements of this depression was that during its progress down the eastern coast of Great Britain the barometer not only rose in its rear but also in its centre, the minimum readings being half-an-inch higher on the morning of the 18th than they were on the previous morning. The remarkable way in which the wind rose at Deerness was noteworthy, the increase being from 14 miles in one hour to 46 in the next, and then to 81 miles in the third hour. On August 20th, 1889, a similar but rather greater increase of wind force was recorded at Fleetwood, the velocity increasing from 7 miles to 58 miles in consecutive hours.

Mr. H. N. DICKSON said that he first experienced this storm when about 100 miles north-east of the Shetland Isles, on board H.M.S. *Jackal*, and in consequence of the rough weather it became necessary to make for Lerwick Harbour which was reached at 7 a.m. on the 17th. The wind blew strongly from South-south-west all day, but at 7 p.m. it fell to almost a calm. At 7.15 a Northerly gale burst over the harbour with the suddenness of an explosion, and by 8 p.m. it was blowing with hurricane force. The charts showed the position of the centre of the disturbance on the evening of the 17th to have been north-east of Aberdeen, but considering the suddenness with which the Northerly wind burst at Lerwick it seemed probable that the centre was further north than Aberdeen, and nearer Lerwick than the *Pilot Chart* indicated. This storm afforded a good opportunity for study, as the abruptness with which the Northerly gale burst indicated that the centre must have been very well defined. He thought that a consideration of the extent and form of sea disturbance around depressions would be of interest, especially in connection with the storm discussed in Mr. Harding's paper, as he (Mr. Dickson) should have expected a cyclone of such intensity to have raised more sea before it. In the case of what Mr. Harding called the "pilot" disturbance on the 14th, the sea in the neighbourhood of the Shetlands was very considerable, but by the morning of the 15th it was quite calm.

Mr. G. J. SYMONS considered that in the interest of meteorological science it was fortunate that so skilled an observer as Mr. Dickson happened to be within the influence of the storm when it was in the neighbourhood of the Shetlands, as observations from such a source and locality were very valuable. As corroborating the wind records at Deerness, he had been told that at some place in the Orkneys the wind had torn the stack pipe from the wall of a house and blown it through the back door. He should much like to have had the opinion of Mr. W. H. Dines concerning the high velocities registered during this storm. Mr. Dines's father (the late Mr. G. Dines) always refused to believe in the accuracy of these records of great velocities, as from his knowledge of buildings he was

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confident that no structure could withstand such pressures as some anemometers indicated.

Mr. W. ELLIS said that meteorologists and sailors were well aware that in stormy or squally weather the wind will not unfrequently change in direction from South-west or South-south-west to North-west, blowing then with increased force and accompanied usually by rain. There will generally be some degree of pressure before the change of direction with increased pressure at the time of change. On November 17th there occurred a very marked case of the kind. Previously to 5.48 p.m. the wind was South-south-west with no very sensible pressure, but at the time mentioned the direction suddenly changed to West-north-west, with an instantaneous increase of pressure to 8 or 9 lbs. on the square foot, accompanied by rain, the remarkable thing being the extreme suddenness with which the pressure sprung up from an insignificant amount to that mentioned. It was a very noteworthy case of the type of weather in question. The barometer had been falling, but at the instant of this change of wind it turned to rise, and continued generally to rise during the remainder of the gale: the change was, as usual, accompanied by sharp fall of temperature. [The various registers were exhibited to the meeting.] He took the opportunity to mention that during the last summer, by an additional gearing applied to the Osler anemometer at Greenwich, a more rapid motion could at pleasure be given to the sheet, causing it to travel with twelve times the ordinary velocity, for use on the occasion of storms. By this spreading out of the register, the variations, both of direction and pressure of the wind, become apparent in a way that is not possible with the contracted register. [A record obtained with the extended scale was shown.] And it is further evident that a yet more extended register was desirable.

Mr. R. H. SCOTT said that it was exceedingly interesting to notice how completely Mr. Dickson's account of the sudden bursting of the Northerly gale at Lerwick corroborated the remark made by Mr. Spence, the observer at Deerness, who had stated that it was "like the shot of a gun." With reference to the question of the possible use of sea disturbance on our coasts as giving warning of the advance of depressions, in 1869 a station was established at St. Anne's Head, Milford Haven. It had previously been maintained by residents in Pembrokeshire that observations of sea disturbance there gave unerring indication of the approach of storms, but during the 24 years that the station has existed the observations of sea disturbance had never afforded warning of any storm there which was not fully indicated by other observations.

Dr. R. BARNES observed that storms of the character described in Mr. Harding's paper served to equalise the character and temperature of the air over wide areas of country. During the gale on December 12th, he had caught some of the rain in clean glasses at his residence at Lyss, in Hampshire, about 15 miles distant from the sea; and had found that the water collected contained a good proportion of sea salt. This ingredient, easily detected, was an indication of other properties carried in the wind from the sea. It was desirable to extend observations of this kind, illustrating the properties of the air, to more inland districts.

Mr. G. J. SYMONS observed that the most remarkable case of the deposit of salt by a strong wind at places inland occurred at Leeds, some years ago, most of the windows facing south-west having a saline incrustation upon them.

Mr. H. HARRIES directed attention to the fact that this severe gale occurred within a few days of the anniversary of the great storm of 1703, a large amount of information about which he had in his possession—information which was not used by De Foe in describing that memorable hurricane. From a study of the data there is some ground for supposing that De Foe's storm occupied four days in crossing the Atlantic, while the one now discussed by Mr. Harding took seven days. Out on the ocean last month's storm area must have been a very extensive one, for the log of the *Lucania* shows the ship to be experiencing the North-easterly gale on the 13th and 14th, when the centre was distant about 900 miles.

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ON CHANGES IN THE CHARACTER OF CERTAIN MONTHS.

By ALBERT E. WATSON, B.A., F.R.Met.Soc., F.R.A.S.

[Received September 13th—Read December 20th, 1893.]

It has been said that "a 10 years' average would probably be within 5 per cent. of the true mean of a long series of years."[1] Consequently, we are led to expect that, however much the rainfall and mean temperature of any individual month may differ from year to year, the variations in one direction will, in a few years at the most, be met by variations in the other direction; the result being that in a short series of years, here given as 10, these variations will almost cancel one another, and the mean will remain practically unaltered.

Now, if this rule could be depended on, it is evident that, by considering the character of any particular month in past years, we should have some ground for forming a judgment as to the probable character of that month in future years; *e.g.* if we found that it had been abnormally wet or cold for several years in succession, we should know that, within a very short time, it must necessarily become abnormally dry or hot, in order to restore the balance, or else that the average would be maintained by a longer series of months of an opposite but less extreme character.

But though, in most cases, this is what actually does happen, in some the average is not by any means maintained, so that after a time the nature of a month becomes completely changed, from wet to dry, or from warm to cold, without, apparently, any prospect of a return to its former condition.

To illustrate my meaning, let us take instances from records kept at Croydon, Surrey, as to the reliability of which there can be no manner of doubt.

First, changes in Rainfall.

Taking the records for January in periods of 5 years from 1866 to 1890, we find the following values:—

	Ins.		Ins.		Ins.		Ins.		Ins.
1866	3·68	1871	2·87	1876	1·04	1881	1·11	1886	3·19
1867	3·12	1872	5·54	1877	5·57	1882	1·20	1887	1·63
1868	4·81	1873	4·08	1878	1·14	1883	1·91	1888	·82
1869	2·91	1874	1·15	1879	2·61	1884	2·49	1889	1·16
1870	1·43	1875	3·49	1880	·40	1885	1·94	1890	2·55
Average	3·09		3·43		2·15		1·73		1·87

Hence the rainfall for this month, so far from maintaining its average, has gradually fallen off during these 25 years from a mean of 3·09 ins. for the

[1] Mr. Symons, at a meeting of the Institution of Surveyors, on February 12th, 1877.

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first lustrum to a mean of 1·87 in. for the last; or, more striking still, from a mean of 3·26 ins. for the first decade to a mean of 1·80 in. for the last. January has in fact lost nearly 50 per cent. of its rainfall, and instead of being, as it was from 1866 to 1875, by far the wettest month of the year, it has been, from 1881 to 1890, almost, if not quite, the driest.

December is another case in point.

Here the rainfall records, arranged in the same way, are the following :—

	Ins.		Ins.		Ins.		Ins.		Ins.
1866	1·85	1871	1·65	1876	7·48	1881	2·77	1886	4·29
1867	1·61	1872	4·39	1877	1·81	1882	1·96	1887	1·39
1868	4·50	1873	·36	1878	1·46	1883	·57	1888	1·45
1869	3·38	1874	1·80	1879	·92	1884	2·21	1889	1·34
1870	3·03	1875	1·22	1880	3·01	1885	1·13	1890	·78
Average	2·87		1·88		2·93		1·73		1·85

Here the average for the whole series is exactly 2·25 ins., but the average for the last 2 lustra is only 1·79 in., a decrease of 20 per cent. on the whole.

For November the result is quite the reverse, the records being the following :—

	Ins.		Ins.		Ins.		Ins.		Ins.
1866	1·48	1871	·55	1876	2·67	1881	3·54	1886	3·22
1867	·62	1872	3·50	1877	5·05	1882	2·13	1887	4·68
1868	1·15	1873	2·54	1878	3·77	1883	3·56	1888	3 91
1869	2·53	1874	2·59	1879	1·20	1884	1·45	1889	·88
1870	1·89	1875	3·15	1880	2·30	1885	2·71	1890	2·03
Average	1·53		2·47		3·00		2·70		2·94

In this case the mean for the 25 years is just over 2·5 ins.; the mean for the first 10 is 2·00 ins., the mean for the last 15, 2·88 ins. Hence the mean rainfall for this month during the 15 years 1876 to 1890 was not only 14 per cent. greater than the mean for the whole period, 1866 to 1890, but actually 42 per cent. greater than the mean for the ten years 1866 to 1875.

So also in May, the mean for the first 2 lustra, 1866 to 1875, was 1·58 in., but the mean for the last 3 lustra, 1876 to 1890, was 1·96 in. indicating an increase of 28 per cent. on the mean of the first 10 years.

Before leaving this subject, it may be interesting to notice how remarkably deficient in rainfall recent Septembers have been. For this month, the averages for the 4 lustra from 1866 to 1885 were practically the same, viz. 2·79 ins., 2·86 ins., 2·70 ins., and 2·82 ins. respectively, or 2·79 ins. for the whole 20 years, of which not one had a rainfall of less than 1 inch. Now since 1885 the fall has been as follows :—1886, 1·78 in.; 1887, 2·40 ins.; 1888, ·85 in.; 1889, ·98 in.; 1890, ·61 in.; 1891, ·68 in.; 1892, 2·04 ins. These figures give a mean of 1·88 in. both for the fifth lustrum and also for the 7 years, of which 4 in succession had a rainfall, hitherto unrecorded in this

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month at Croydon, of less than an inch, while the decrease from the above average is 53 per cent.

The rainfall returns from 1867 to 1876 are taken from Mr. G. Corden's book, *The Meteorology of Croydon;* those from 1877 to 1888 were kindly supplied by Mr. Baldwin Latham, of Addiscombe, and the rest, excepting for 1866, are from my own records at "The Whitgift Grammar School," Croydon. And the points at which they were taken vary very slightly in height above sea-level, and are about a mile apart from one another. For the year 1866 the rainfall is that measured at the Greenwich Observatory.

Secondly, changes in Temperature. Taking the Croydon records of the mean temperature of December from 1876 to 1890 we get the following values :—

	°		°		°
1876	44·2	1881	39·4	1886	36·2
1877	39	1882	39·2	1887	37·6
1878	33·4	1883	39·5	1888	41·1
1879	32	1884	40·6	1889	37·7
1880	43·2	1885	38·4	1890	28·9
Average	38·4		39·4		36·3

The average for the 15 years is 38°·0

Now the mean temperature of December at Greenwich for the 60 years, 1814 to 1873, is given as 39°·9 ;[1] consequently, if we may be allowed to compare the mean temperatures at Croydon with that,—and, considering the nearness of the two places, this seems very reasonable,—the result shows a decrease in mean temperature of 1°·9.

But the mean temperatures of January at Croydon for the same series of years are the following :—

	°		°		°
1876	37·3	1881	31·2	1886	35·3
1877	42	1882	39·9	1887	35·1
1878	40·3	1883	40·6	1888	37·7
1879	32	1884	43·2	1889	37·1
1880	33·4	1885	35·9	1890	43·7
Average	37·7		38·2		37·8

The average for the 15 years is 37°·7.

For Greenwich the mean temperature of January for the above named 60 years is given as 37°·1, so that, instituting the same comparison as before, a rise is here shown of 0°·6. But the remarkable part is, that without comparing Croydon temperatures with Greenwich at all, the average mean temperatures of December and January for the 15 years 1876 to 1890 are almost the same. That is, December has now become as cold as January,

[1] Glaisher, *On the Mean Temperature of Every Day*, 1814 to 1873.

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whereas, according to the Greenwich records, there used to be a difference of practically 8°!

October is another month that appears to have become much colder of recent years. The mean temperature of this month is given in the Greenwich records as 50°·1, but the mean for the three lustra 1876 to 1890 at Croydon is only 49°·2, indicating a mean annual decrease of almost a degree. Indeed, a mean temperature of 50° was reached by October only 6 times in these 15 years. October 1892 was also very cold, with a mean temperature of only 46°·1.

These facts seem to show that a 10 years' average is not by any means always maintained, but that on the contrary the character of particular months may change, as time goes on, to a very marked extent. For as we have shown, December has lost 20 per cent. and November gained 14 per cent. on the average rainfall of 25 years, while October is nearly a degree colder than it used to be, and January, which was the wettest and coldest month in the year, has now become almost the driest, and no colder than December, which month has lost nearly 2° in mean temperature. Are these changes local, or have all the stations in the British Isles been similarly affected?

DISCUSSION.

Mr. G. J. SYMONS said that the quotation given at the commencement of the paper did not quite correctly represent the statement he made in an address to the Institution of Surveyors in 1877, which referred to the *annual* rainfall values and not to the values for individual *months*.[1] Monthly averages of various sets of years differed tremendously, but he had said nothing about them.

Mr. C. HARDING said that there were many facts of interest in Mr. Watson's paper, but too much importance had been given to observations which extended over a very short period. It was hardly wise to use sometimes Greenwich observations, sometimes Mr. Latham's observations, and sometimes observations made by the author himself. It would have been more satisfactory if Greenwich records alone had been used throughout, and these were available for a long series of years.

Mr. BALDWIN LATHAM remarked that the earlier observations at Croydon were not very reliable, the method of exposure of the instruments having been unsatisfactory. Possibly some of the differences shown in the paper might be due to that cause.

Mr. H. SOUTHALL said that his experience in connection with Herefordshire observations had taught him that an average of 5 or 10 years would not afford reliable results for monthly values, and even for yearly amounts there were often great divergences between averages deduced from a short term of years. For instance the mean rainfall of one period of 12 years at Ross was 27 ins., while the succeeding 12 years yielded an average of 32 ins.

Mr. A. E. WATSON, in reply, said that Mr. Symons' statement, as quoted in his (Mr. Watson's) paper, had been copied from a book, but he had at the time wondered whether Mr. Symons was referring to annual values merely. He had used the different sets of rainfall observations for Croydon, because he thought as the stations were in such close proximity to each other that the results would be fairly comparable. The temperature observations used were supplied by Mr. Baldwin Latham, of Addiscombe.

[1] The words were "the rainfall of a single year may be 33 per cent. either above or below the true average, a two years average may be 16½ per cent. above or below, and so on, the approximation decreasing less rapidly, so that at the end of ten years the average will probably be within 5 per cent. of the true mean of a long series of years."

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RAINFALL AND EVAPORATION OBSERVATIONS AT THE BOMBAY WATER WORKS.

By S. TOMLINSON, M.Inst.C.E., F.R.Met.Soc.

(Abridged.)

[Received May 29th.—Read December 20th, 1893.]

Bombay is situated in about 18°53′45″ N. lat. and 72°48′56″ E. long., these figures giving the exact situation of Colaba Observatory. The municipal limits are the Island of Bombay, as it is now called; but great physical changes have in recent times been brought about by engineering works. On the east the Island is separated from the mainland by the Harbour, about 6 miles wide: on the north it is, or rather was, separated from the larger Island of Salsette by a narrow creek, but four embankments now carry the two railways and two roads leading out to the mainland. In the Island of Salsette are situated the works which up to March 1892 supplied the Island of Bombay with water. In 1892 the Tansa Works were opened: these works comprise the Tansa Lake, about 60 miles distant from the Town Hall at Bombay, and a duct bringing in water from Tansa Lake to Bombay. The Tansa Lake is on the mainland of India, and is situated in one of the valleys leading out from the Western Ghats which run on the mainland north and south about 40 miles eastwards from Bombay, and rise opposite to Bombay to over 3,000 feet above sea level.

The climatology of Bombay has been the subject of a large and complete work by Mr. Charles Chambers, F.R.S., Director of the Government Observatory, Colaba, a copy of which work is in the Society's Library.

The accompanying wind chart, reproduced by kind permission from Mr. Baldwin Latham's *Sanitation of Bombay*, and Table I., show the prevailing winds; and as the changes from year to year are comparatively small, the representation is sufficiently accurate for general purposes. The full line represents the frequency of the wind, and the dotted line the proportional velocity.

Roughly speaking, the winds are from the sea (South to North-west) from March to October; and from the land from November to February, and they bring heavy rain in the months of June, July, August, and September, with the probability of some rain in May and October; and there is a possibility of showers in the remaining months.

As no observations on Relative Humidity have been taken at the water works, Table II. is inserted with the kind permission and assistance of Mr. Chambers.

Table III. gives the rainfall registered at Colaba Observatory from 1848 to 1892.

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TABLE I.—Direction, and Frequency of Winds at Colaba, Bombay, for the Fifteen Years, 1873–1887.

Direction.	Average Frequency.	Direction.	Average Frequency.
	Days.		Days.
N.....	25·7	SSW	8·2
NNE	18·0	SW.....	14·0
NE.....	23·5	WSW.....	34·6
ENE	19·6	W	50·5
E.....	8·8	WNW.....	42·9
ESE	8·9	NW	52·2
SE	5·3	NNW	40·1
SSE	6·6		
S.....	6·3	Total	365·2

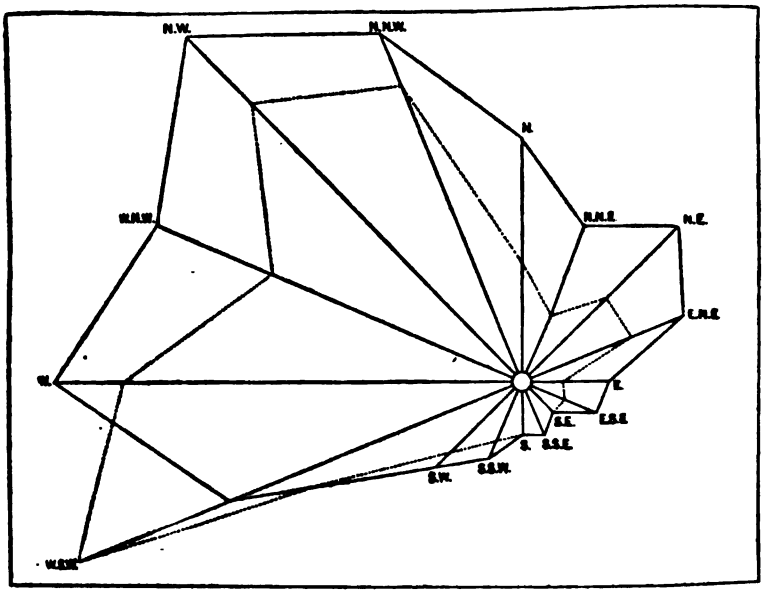

TABLE II.—Average Relative Humidity, 1855–1864, and Temperature of the Air 1873–1892, at Colaba Observatory.

Month.	Relative Humidity.			Temperature.			Month.	Relative Humidity.			Temperature.		
	Min.	Mean.	Max.	Min.	Mean.	Max.		Min	Mean.	Max.	Min.	Mean.	Max.
	%	%	%	°	°	°		%	%	%	°	°	°
January	51	72	89	55·2	73·9	88·6	August ..	77	87	98	71 9	80·0	86·5
February	44	71	89	56·9	74·8	94·8	September	71	86	99	73·1	79·9	88·9
March ..	55	74	88	67·2	78 7	95·4	October ..	62	81	94	70·5	80·7	93·8
April	61	75	86	72·0	81·9	92·2	November	50	72	91	66·1	78 6	93·4
May	65	75	91	74·1	84·2	96·5	December	43	70	89	63·2	75·7	89·4
June	67	83	98	73·2	82·9	91·9							
July	76	88	100	73·7	80·7	88·8	Year ..	43	77·8	100	55·2	79·3	96·5

The Colaba Observatory is situated on the low ridge of land forming the

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old Island of Colaba, now joined to the Island of Bombay. It is only 128 feet above Town Hall Datum. This Datum is 100 feet below a certain step on the Town Hall, and this step may be taken as an average rough memory level for the central part of the Island of Bombay, the basalt ridges on the east and west sides of the Island culminating at about 260 feet above Town Hall Datum on the west (Malabar Hill Reservoir), and 240 feet above Town Hall Datum on the east (Cliff over Bhandarwada Reservoir). The mean sea-level is 80·16 feet Town Hall Datum.

TABLE III.—RAINFALL AT COLABA OBSERVATORY FOR THE FIFTY YEARS, 1843–1892.

Years.	Rainfall.	Ratio Average = 100.	Years.	Rainfall.	Ratio Average = 100.	Years.	Rainfall.	Ratio Average = 100.
	Ins.			Ins.			Ins.	
1843	55·24	76	1860	62·15	86	1877	69·89	97
1844	62·71	87	1861	76·91	107	1878	111·93	155
1845	54·12	75	1862	73·63	102	1879	61·40	85
1846	73·93	102	1863	77·68	108	1880	67·94	94
1847	76·00	105	1864	45·57	63	1881	73·04	101
1848	75·86	105	1865	77·85	108	1882	69·23	96
1849	114·89	159	1866	78·44	109	1883	90·18	125
1850	50·25	69	1867	62·30	86	1884	75·44	105
1851	96·07	133	1868	62·12	86	1885	67·91	94
1852	69·27	96	1869	91·66	127	1886	99·74	138
1853	62·60	87	1870	66·21	92	1887	94·95	132
1854	82·14	114	1871	40·58	56	1888	57·82	80
1855	41·18	57	1872	76·48	106	1889	67·84	94
1856	65·92	91	1873	69·70	97	1890	65·18	90
1857	51·27	71	1874	82·18	114	1891	77·18	107
1858	62·45	87	1875	83·09	115	1892	95·12	132
1859	77·16	107	1876	50·04	69			

Average Rainfall for the 50 years, 71·84 ins.

The observations at Colaba are quite independent of the Water Works, and are inserted as a complement to the observations on the Water Works with a view to making a study of the latter more useful and complete.

RAINFALL.

Vehar Lake Observations. The Vehar Lake was built immediately preceding and during the period of the Indian Mutiny (1856-59), and water was first supplied to the City of Bombay in 1860. There is a rainfall record from 1861, results of which are given in Table IV.

There are 4 rain gauges, viz. :—A is situated near the top of the slope of the main embankment, in a completely exposed situation, the funnel of the gauge being 8ft. 4ins. above the pitching of the embankment, and about 7 ft. above the top of the embankment. B is situated on the eastern side of the lake, about 50 feet distant from the top water line; the site is clear, sloping upwards to the south-east. The funnel of the gauge is 8 feet above the ground. C is situated to the north-east of the lake on a clear site, about 40 feet distant from the top water line of the lake. The funnel of

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the gauge is about 10 ft. 5 ins. above the ground level. D is situated on the western side of the lake at the top water line. The funnel of the gauge is 10 ft. 1 in. above the ground. The exposure is slightly interfered with at present by trees, and the gauge will be moved a few feet so as to be quite free from the interference of the trees.

TABLE IV.—RAINFALL AT VEHAR LAKE, 1861–92.

Years.	Rainfall.	Years.	Rainfall.	Years.	Rainfall.	Years.	Rainfall.
	Ins.		Ins.		Ins.		Ins.
1861	105·4	1869	91·69	1877	62·71	1885	76·35
1862	96·4	1870	64·97	1878	120·79	1886	104·65
1863	117·1	1871	40·89	1879	76·04	1887	92·86
1864	83·2	1872	65·93	1880	72·42	1888	76·71
1865	88·8	1873	83·72	1881	59·10	1889	85·24
1866	75·0	1874	93·73	1882	54·63	1890	100·04
1867	79·9	1875	74·25	1883	99·54	1891	89·87
1868	70·2	1876	65·68	1884	87·65	1892	129·38

Average Rainfall for 32 years, 83·90 ins.

The water collected in each of the gauges is removed at 6 a.m. by a native watchman, poured into a separate bottle, and carried to the inspector, who measures the quantity in the measuring glass. The 4 quantities are added together and then divided by 4, the quantity entered for the day being therefore the average of 4 gaugings in different parts of the lake, and the yearly total given is the total of such daily averages.[1] So far as the Author has been able to ascertain, the reading at 6 a.m. has always been entered as the reading for the date attached to that day, instead of for the date of the preceding day.

Tulsi Lake Observations. A similar system has been observed at Tulsi Lake, but the works there are more recent, and the record dates only from 1880 (Table V.). Gaugings were taken previous to that, but the record of them appears to have been lost. There are 3 gauges at Tulsi, E, F, G.

E is situated on the western side of the lake, about 50 feet from the water edge and 15 feet above it. Trees interfere with the exposure of the gauge, although not actually overhanging it. The gauge is 5 ft. 6 ins. above the ground. F is situated on the main embankment, and is freely exposed, the funnel is 6 ft. above the surface of the ground. The funnel of the gauge is at about 468 ft. above Town Hall Datum. G is situated near the Bungalow, at an elevation of about 640 ft. above Town Hall Datum. It is near the summit of the hill, which rises rapidly from the water level and is freely exposed to the west and south. The funnel of the gauge is 5 ft. 4 ins. above the ground.

All the gauges, A, B, C, D, E, F, and G, are bottle gauges, with funnels 4½ ins. diameter. Alongside of each is a Crossley's self-recording gauge, but as the readings of the latter are always less than those of the bottle gauges, they are not taken into the totals.

[1] In the gauges recently established by the Author in the adjoining Pawai Valley the readings of each gauge are separately recorded.

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TABLE V.—RAINFALL AT TULSI LAKE 1881–92.

Level of Waste Weir, as raised 1885....456·50 ft. above T. H. Datum.
" Lowest Inlet to Tower.....399·36 "

Years.	Rainfall.	Years.	Rainfall.	Years.	Rainfall.	Years.	Rainfall.
	Ins.		Ins.		Ins.		Ins.
1881	84·26	1884	94·84	1887	95·86	1890	116·09
1882	74·24	1885	82·57	1888	89·08	1891	99·47
1883	109·46	1886	108·42	1889	92·91	1892	144·15

Average Rainfall for the 12 years 99·28 ins.

Pawai Lake Observations. The 2 gauges in the Pawai Valley were only established in 1890. They are bottle gauges 5 ins. in diameter. The funnels are placed 1 foot above the level of the ground. The Pawai gauge is near the village of Pawai, on a small island in the lake, at about 198 feet above Town Hall Datum; and the Goper Valley gauge is near the engine house on a clear site, at a level about 163 feet above Town Hall Datum.

Rainfall at Pawai Lake 1890-92.

	Ins.		Ins.		Ins.
1890	93·33	1891	89·20	1892	122·27

Tansa Lake Observations. These observations date from 1886. The rain gauge is fixed on the ridge of the hill into which the southern end of the dam is tied. The site is clear, declining to north and south. The funnel of the gauge is 2 ft. 11ins. above the level of the ground; it is protected by plank fence, at 8 ft. distance, 2 ft. in height. The gauge is 5 ins. diameter. The level of the funnel above Town Hall Datum is 428·76 ft.

Rainfall at Tansa Lake 1890-92.

	Ins.		Ins.		Ins.
1887	106·49	1889	91·44	1891	80·66
1888	86·81	1890	99·47	1892	109·40

EVAPORATION.

The Malabar Hill Reservoir is roofed over. The evaporation taking place from a wooden box, 10 ins. square, 18 ins. deep, placed under the roof, but not in the water, was in May 1888 one-twelfth of an inch per day.

At Bhandarwada Reservoir the only observations made up to the present were in May and June 1891, in connection with the testing of the uncovered filters for leakage after repairs. Filter No. 6 is immediately adjoining the vertical cliff on the east, which was formed by blasting away the rock so that the Reservoir works should be upon the uniform level of 190 ft. above T.H.D. top water level. The boxes employed were of tinned plate, as used for kerosine oil, and each was tested for water tightness before being put into the filter basin; one wooden box was used in one filter alongside the tinned box. The details of the observations (in this case made by the Author) are given in Table VI.

The Cushions Nos. 1 and 2, from which it will be observed the evaporation

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was less than from any of the boxes, are not freely exposed to the north, being 8 ft. 6 ins. below the coping of the wall and thereby shielded from the prevailing wind at the time the observations were taken. As remarked above, No. 6 is probably greater on account of the proximity of heated rock.

The results are important only as indicating what is the maximum evaporation from comparatively small sheets of water during the hottest part of the year; and as illustrating the difficulty of obtaining reliable results from small boxes accessible to birds. The filters are visited by considerable numbers, and the boxes attract special attention. It will be noticed that the loss from the basins 1, 2, and 4 (and 5 for part of the period) was less than that from the evaporating boxes, even supposing the basins to be absolutely watertight.

TABLE VI.—EVAPORATION FROM THE BHANDARWADA FILTERS. (EACH FILTER IS 200 FEET LONG BY 80 FEET BROAD.)

Period.	Filter.	Evaporation.
	Ins.	Ins.
Total Evaporation for May 1891, based on observations from		
Filter No. 1, 5th to 16th	10·54	13·21
Filter No. 2, 11th to 16th	11·10	13·83
„ No. 4, 22nd to 1st June	10·94	12·78 wood. 13·67 tin.
Evaporation for June—		
Cushion Filter No. 1, 1st to 17th	7·73	..
„ No. 2 „ „	8·20	..
Filter No. 3 „ „	13·32	..
„ No. 4 „ „	10·74	9·00 wood.
„ No. 5 „ „	11 46	12·41
„ No. 6 „ „	14·13	12·47

Mint Tank. In September and October 1887 some observations were made of the loss from the tank attached to the Mint in Bombay, which is 258 ft. diameter and fully exposed. The experiments were not conclusive, but, so far as they can be used, indicate an evaporation of over one quarter of an inch per day. The Author does not consider that the observations should be seriously considered, as the temperature of the water in this tank was above that of the air, the water being used for condensing purposes. A further objection is that the water level at the time of the observations was about 10 feet below the coping of the wall, and the air circulation was thereby interfered with, as well as the exposure to the sun.

Vehar Lake. Top water level 268·5 ft. above T.H.D.

The observations of evaporation were commenced at Vehar on November 8th, 1890. The box used is of wood, painted; 10 ins. square, 18 ins. deep. At the commencement of each month the water is filled up to a depth of 14 ins., and the observations are made daily. Two boxes are now maintained. In one the water level is started at the beginning of the month 1½ ins. above the water in the lake; and in the other 1½ ins. below. This plan is adopted as a check against leakage. The boxes are placed at a short distance from the shore, where they can be stayed, and are believed to be free of gain or loss from wave splashing.

Tulsi Lake. Top water level 456·50 ft. above T.H.D.

The observations were commenced on January 1st, 1891. During 1891,

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TABLE VII.—Monthly Totals of Evaporation at different places, in 1890, 1891, 1892 and 1893.

Month.	Vehar Lake.								Tulsi Lake.					Tansa Lake. Water Area about 3,000 acres.			Pawai Lake. Water Area about 300 acres.								
	1890.		1891.		1892.		1893.		1891.	1892.		1893.		Gross Fall of Surface of Water in the Lake: no inflow.			1890.	Small Inflow percolation from Vehar.			1891.		1892.		1893.	
	No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 1.	No. 2.	No. 1.	No. 2.	1890.	1891.	1892.	Gross Fall of Surface of Water in the Lake.	1891.	1892.	1893.	No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.
	Ins.		Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.		Ins.	Ins.	Ins.	Ins.
Jan. ..	..	No. 2 box not fixed.	5·50	..	5·00	5·00	3·87	3·87	6·5	3·87	..	3·87	3·87	..	5·28	4·44	..	2·48	6·3	4·8	5·25	..	3·87	3·87	3·87	3·87
Feb. ..	..		5·25	5·25	4·37	4·37	..	..	5·5	4·75	..	..	..	7·56	5·64	8·88	..	..	..	..	3·25	..	3·62	3·62	..	..
March	..		6·00	5·37	6·5	6·5	..	..	7·75	4·25 ?	..	..	..	6·48	7·56		..	..	..	..	..	..	6·00	6·00	..	..
April ..	..		5·25	5·37	7·5	7·5	..	..	7·87	4·50 ?	..	..	..	6·84	7·68		..	..	..	..	..	..	7·50	7·50	..	..
May ..	..		7·00	6·75	7·75	7·75	..	..	8·25	3·87 ?	..	..	..	9·72	9·36		..	..	..	..	..	..	7·75	..	..	..
June ..	..		..	..	..	..	..	..	5·25[5]	..	..	..	..	..	4·92[7]		..	..	..	..	..	..	..	..	..	..
July ..	..		..	..	..	..	..	..	..	..	..	..	..	..	..		..	..	..	..	..	..	..	..	..	..
Aug. ..	..		..	..	..	..	..	..	..	..	..	..	..	..	..		..	..	..	..	..	..	..	..	..	..
Sept. ..	..		..	..	..	..	..	..	..	..	..	..	..	..	..		..	..	..	..	..	..	..	..	..	..
Oct. ..	..		4·17[8]	4·05[4]	..	..	..	..	5·42[6]	..	..	..	..	5·86	4·68		..	8·4[9]	..	..	..	..	..	..	..	..
Nov. ..	2·75[1]		4·37	4·00	4·5	4·5	..	..	4·25	3·75	3·75	..	..	5·04	6·24		..	9·0[9]	4·5	4·75	4·75	..	3·75	3·75	..	..
Dec. ..	4·25[2]		5·62	5·50	3·87	3·87	..	..	3·87	3·87	3·87	..	..	3·32	5·16		4·80	6·0	5·1	4·62	4·62	..	3·87	3·87	..	..

[1] 8th to 30th. [2] Evap. 3·75, Rain ·50, 4·25. [3] Evap. 3·62, Rain ·55, 4·17. [4] Evap. 3·50, Rain ·55, 4·05. [5] 1st to 20th. [6] Evap. 5·00, Rain ·42, 5·42. [7] Rain. [8] 1st to 18th. [9] Water flows over waste weir by wind.

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and up to November 1892, there was only one box in which the water was kept about 1½ ins. above that of the water in the lake. The box is similar to those at Vehar. In November 1892 the position of the boxes was altered, as the former position was exposed and splashing took place. The readings, which by this wind action have been rendered rather doubtful, are indicated by a ?

Pawai Lake. Top water level 190 ft. above T.H.D.

The observations were commenced on January 1st, 1891, but as the lake was run off later in the year, the record is broken.

Direct observations of the evaporation from the Vehar and Tulsi lakes are not practicable, because the quantity drawn off and the area of the water surface at different levels are not known with sufficient accuracy to place calculated results beyond doubt.

Tansa Lake. No direct observations of evaporation have been made, but during construction, water was stored to increasing depths after each season's work, and the levels of the water on the 1st of each month in 1890, 1891, and up to 1892, are given in Table VII. (p. 69).

Evaporation during the Monsoon. No opportunity has occurred for determining the evaporation from large areas of water during the Monsoon. Such figures, however, as have been obtained tend to show that evaporation in the Monsoon proceeds at a much greater rate than is generally supposed. The rain gauges, being at an elevation of several feet above the ground, probably register less than if placed on the water level, the same as the evaporation boxes. The figures show that the evaporation boxes have almost invariably indicated evaporation even on days when rain fell. Further experience may help to fix the quantity. The figures confirm those given in Beardmore's *Hydrology;* and probably ordinary evaporation boxes would be comparatively free from error due to birds drinking during the Monsoon, because they may drink almost anywhere and at any time.

TABLE VIII.—APPROXIMATE MONTHLY AVERAGE EVAPORATION IN INCHES WHICH MIGHT BE EXPECTED FROM SURFACES OF WATER IN THE NEIGHBOURHOOD OF BOMBAY.

Month.	From a small surface, say 1 square foot.	From a Reservoir of say 10,000 square feet.	From a Lake of 300 to 3,000 acres.
	Ins.	Ins.	Ins.
January	7·5	6·5	5·0
February	7·0	6·0	5·5
March	9·0	8·0	6·0
April	10·0	8·5	7·5
May	12·0	10·0	8·0
June	5·0	5·0	5·0
July	3·5	3·5	3·0
August	4·0	4·0	4·0
September	4·5	4·5	4·0
October	7·0	6·0	5·0
November	8·0	7·0	4·5
December	8·0	7·0	5·0
Year	85·5	76·0	62·5

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PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

November 15th, 1893.

Ordinary Meeting.

C. THEODORE WILLIAMS, M.A., M.D., President, in the Chair.

ARCHIBALD WILSON ANDERSON, Chief Weather Bureau, Brisbane;
SHELFORD BIDWELL, M.A., LL.B., F.R.S., Riverstone Lodge, Southfields, S.W.;
RICHARD BAXTER BOOTH, LD.S., 9 Market Square, Crewe;
JOHN MITCHELL BRUCE, M.D., F.R.C.P., 70 Harley Street, W;
ROBERT HENRYSON CAIRD, Southbroom House, Devizes;
JOHN HENRY CHALONER CHUTE, Ballinasloe, Co. Galway;
FRANCIS DRUCE, Upper Gatton, Merstham;
REV. FRANCIS HARVIE, FOWLER, M.A., Barnwood, Gloucester;
EDWARD LEADER HANNA, Rockhampton, Queensland;
GEORGE HENRY HILL, M.Inst.C.E., 8 Victoria Street, S.W.;
WALTER CUNNINGHAM HUME, Government Lands Office, Brisbane;
CHARLES JOHN LEESON, Croydon, North Queensland;
JOHN MICHAEL NICHOLLS, L.R.C.P., St. Ives, Cornwall;
HENRY FRANKLIN PARSONS, M.D., 4 Park Hill Rise, Croydon;
GEORGE VICTOR PEREZ, M.B., M.R.C.S., Puerto Orotava, Teneriffe;
JOHN BARWISE SCURFIELD, Mitchell, Queensland;
SAMUEL SINNAMON, Junction Creek, North Queensland;
FRANCIS DRUMMOND GREVILLE STANLEY, F.R.I.B.A., Brisbane;
DERWENT HUTTON RYDER WALDRON, M.B., C.M., Accra, Gold Coast;
JOHN GEORGE WALLER, 118 Powis Street, Woolwich; and
JAMES GEORGE WOOD, M.A., LL.B., F.G.S., 115, Sutherland Avenue, W.,
were balloted for and duly elected Fellows of the Society.

The following Papers were read:—

"THE GREAT DROUGHT OF 1893 AND ITS ATTENDANT METEOROLOGICAL PHENOMENA." By FREDERICK J. BRODIE, F.R.Met.Soc. (p. 1.)

"THUNDER AND HAILSTORMS OVER ENGLAND AND THE SOUTH OF SCOTLAND, JULY 8th, 1893. By WILLIAM MARRIOTT, F.R.Met.Soc. (p. 31.)

December 20th, 1893.

Ordinary Meeting.

C. THEODORE WILLIAMS, M.A., M.D., President, in the Chair.

ROBERT ELLIS LORD, M.D., B.Sc., M.R.C.S., Abergele Road, Colwyn Bay; and
Capt. GEORGE P. SCOTT, 41 Hartington Road, Liverpool,
were balloted for and duly elected Fellows of the Society.

Mr. J. S. HARDING and Mr. A. E. WATSON were appointed Auditors of the Society's Accounts.

The following Papers were read;—

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"THE GREAT STORM OF NOVEMBER 16TH-20TH, 1893." By CHARLES HARDING, F.R.Met.Soc. (p. 48.)

"ON CHANGES IN THE CHARACTER OF CERTAIN MONTHS." By A. E. WATSON, B.A., F.R.Met.Soc. (p. 59.)

"RAINFALL AND EVAPORATION OBSERVATIONS AT THE BOMBAY WATERWORKS." By S. TOMLINSON, M.Inst.C.E., F.R.Met.Soc. (p. 68.)

CORRESPONDENCE AND NOTES.

Comparison of the Readings of two sets of Maximum and Minimum Thermometers in a Stevenson Screen.—Mr. J. Lovel, of Driffield, writes:—"Having had in my possession since 1890 two pairs of maximum and minimum thermometers by different makers, mounted in the same screen, a new pattern Stevenson, I thought it might be useful if I compared their readings for a period when all the instruments were read and set at 9 a.m., the Climatological plan, and also when one pair was read and set at 9 a.m. and the other read and set at 9 p.m., the Second Order plan. This has now been done during the past year 1893, and the results are interesting.

From May 1890 to the end of December 1892, both pairs of thermometers were read and set at 9 a.m., and although the maximum is a Standard instrument by Casella, with Kew certificate, I found it necessary to apply a correction of 1°·0 to bring it into accordance with the other maximum by Negretti and Zambra. When this was done, the instruments were practically identical in their readings with an average difference per month of only 0°·003 in 1892.

The minimum thermometer readings were also fairly regular, an average difference of only 0°·006 per month was obtained, although one of them is regarded as an extra sensitive instrument, being a Casella's Link pattern (no index errors).

When the instruments had been sufficiently brought into agreement with each other, at the beginning of 1893, one pair was read and set as usual at 9 a.m. and the other pair read and set at 9 p.m. As a final result of the experiment in the twelve months of 1893, it was found that the maximum when read at 9 p.m. averaged 0°·194 per month lower than when read and set at 9 a.m.; and that the minimum also averaged 0°·309 lower. A somewhat similar result is shown, though in a smaller degree, in a paper by Mr. Ellis in the *Quarterly Journal*, Vol. XVI. p. 213; the Second Order average maximum there given being 0°·06 below the Climatological average maximum, and the Second Order average minimum 0°·08 below the Climatological average minimum on the three and four years' averages respectively. Taking the individual years, the differences are —0°·08, —0°·04 and —0°·10 for the maximum temperature, and —0°·26, +0°·06 and —0°·11 for the minimum in the years 1886, 1887, and 1888, showing on the whole a decided tendency of the Climatological method of recording temperature to give a slightly higher reading than the Second Order system.

Perhaps a further series of observations might modify the results, but the indications, so far as present observations go, clearly point to a slight lowering of the mean annual temperature from stations of the Second Order when compared with those on the Climatological plan."

Hailstorm in Lincolnshire, August 22nd, 1893.—On this date a remarkable storm of rain and ice occurred between 4 and 4.30 p.m. over a small district on the Lincolnshire Wolds bounded on the south by Fotherby, South Elkington, Welton, Biscathorpe, and Hainton, and on the north by Ludford, Kelstern, North Ormsby, and Utterby. In this space of about 10 miles east to west, and 2 to 3 miles north to south, much damage was done to corn crops, gardens, and glass. A party driving barely escaped an upset, as the horse was paralysed by the force of the storm. Their dog was killed on the road, and many chickens were beaten to death in the farmyards. At Hainton Hall gardens the ice was gathered up

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by the barrow load, pieces in some parts remaining unmelted until next morning.

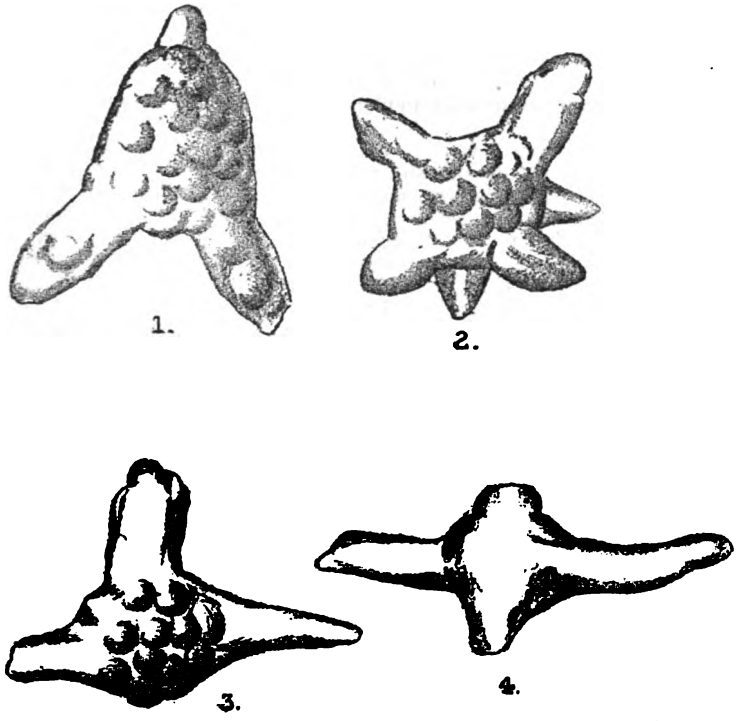
The Rev. J. M. Coates made the accompanying sketches of some of the stones which fell at Welton-le-Wold at 4.30 p.m.

Fig. 1 weighed 90 grains 15 minutes after it fell.

Fig. 2 was drawn 42 minutes after it fell.

Fig. 4 measured $2\frac{3}{16}$ ins. in length 50 minutes after it fell.

In Figs. 1, 3, and 4 the projections were all roughly in one plane. In fig. 2 the projections extended from all sides.



Hail Stones (actual size) which fell at Welton-le-Wold, Lincolnshire, August 22nd, 1893.

The largest stones remaining on the grass lawn were not quite melted away after two hours. The temperature of the air was probably about 70° at 4.30 p.m. There was no appearance of crystalline structure in any of the hailstones examined, but rather of aggregation of globular stones of small size in the projections as well as in the globular nuclei.

Thunderstorm Phenomena.—Mr. H. Bedford, of Newton Abbot, Devon, writes under date of December 12th, 1893: "We were visited this morning by a curious thunderstorm. The first thing I heard was a *hissing* noise, then a loud report like a cannon. This was repeated three times, finishing off with a long loud report. The whole phenomena appeared to be one obstructed clap of thunder. It was followed by great stillness for about five minutes, then by a most vivid flash of lightning and ordinary thunder. There was hail, rain, and gusts of wind. This morning is the most wretched looking I ever witnessed. I noticed on Thursday last, I think, a report in one of our local papers that a ball resembling a small moon had been seen in the north direction, descending perpendicularly, and exploding with falling sparks, and someone had also seen a mysterious light the same night in the south."

Heavy Rain at Nice.—Mrs. Sturge writes that she and Dr. Sturge arrived at

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Nice on September 30th, 1893, in such a deluge of rain as has not been known for years. It was calculated that at least 8 ins. fell in the 24 hours ending 9.30 a.m. on October 1st; 7½ ins. were measured, and a considerable quantity had overflowed the rain gauge. *Nice Médical* gives for September 30th 194·4mm.=7·655 ins. from the Avenue des Fleurs (St. Philippe). On the same day the observatoire gave 88·4 mm., the Ecole Normale 157 mm., and the Station Agronomique 178·2 mm. [ED.]

Meteorological Nomenclature.—Prof. Cleveland Abbe, in the *Monthly Weather Review* for August 1893, remarks on the great diversity in the usage of meteorological terms by the daily press and meteorological observers, and states that in the *Weather Review* the following usages will be adhered to:—

The terms "high" and "low" will refer to areas in which barometric pressure is decidedly above or below that of the surrounding country, without reference to any normal values and without implying any specific peculiarity as to winds or weather.

The word "storm" will refer to a disturbance of the ordinary average conditions or to unusual phenomena, and unless specifically qualified may include any or all meteorological disturbances, such as wind, rain, snow, hail, thunder, etc. This word may be qualified by some peculiarity, *i.e.* sandstorm or duststorm (such as the "simoon"), hot wind (such as the "khamsin," or "föhn," or "chinook"), cold windstorm (such as the "norther" and the "pamperos"), cold rainstorm and snowstorm (such as the "blizzard").

A "hurricane" or "typhoon" is a large stormy area, often several hundred miles in diameter, within which violent winds circulate around a centre. The centre of a hurricane or typhoon is a comparatively calm region, where even the clouds break away and the rain ceases, whereas the centre of a thunderstorm is the region of greatest intensity of wind, rain, or lightning.

A "tornado" is a very much smaller region, usually less than two miles in diameter, within which even more violent wind prevails. In the typical tornado these violent winds circulate about a central axis, rapidly ascending at the same time and forming a funnel-shaped cloud whose base is at the average cloud level; but many destructive winds have been classed as tornadoes which are not circulating about such a funnel-shaped cloud or vertical axis, but which are either blowing straight ahead on the earth's surface, as in the "Derecho" or straight line wind, or which have a quasi-rotation around a horizontal axis, as in the blast that accompanies the front of a "norther" or the gust in front of the heavy rain of a thunderstorm. We shall endeavour, as far as possible, to separate the true tornado, which is rare, from the numerous destructive winds, squalls, and gusts which are popularly called tornadoes, hurricanes, cyclones, tourbillons, and other high sounding names.

The term "whirlwind" is applied to any revolving mass of air, and includes at one extreme the hurricane, and at the other extreme the dust whirl of our street corners.

A "cyclone" is a mass of air circulating around a centre; the lower portion of the air near the earth's surface has a vorticose movement in towards a centre, while the upper layers have a movement out from a centre; the line joining the upper and lower centres is the axis of the cyclone; the direction of rotation is the same in both upper and lower layers. In the Northern Hemisphere this rotation is said to be in a negative direction, or opposite to the diurnal motion of the sun in azimuth, and opposite to the movement of the hands of a watch lying with its face uppermost.

An "anticyclone" is a mass of air also circulating around a centre, but the lower layer of air has a movement out from a centre and the direction of rotation is opposite to that of a cyclone, being positive in the Northern Hemisphere.

The terms "cyclone" and "anticyclone" do not describe phenomena that can be observed by one observer or at a single station, they should, therefore, not be used in the description of local phenomena; they represent generalisations based upon the charting and study of winds and clouds observed at many stations, and should only be used when the nature of the rotation of the winds has been clearly demonstrated or can be safely inferred.

The terms "cyclonic winds," "cyclonic system," and "cyclonic rotation" are equivalent to "cyclone." The outer portion of a cyclone generally has feeble winds and fair weather; therefore a hurricane, tornado, or whirlwind is only a small part of a cyclone.

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Rainfall of India.—This is the title of a thick folio volume issued by the Meteorological Department of the Government of India. Previous to the year 1890 there were large differences in the hour of measuring rainfall, in the form of rain gauge used, and in the methods of registering rainfall in the different provinces of India. The want of uniformity in the methods of registering rainfall was due to the fact that the establishment of rain gauge stations and the collection of the data were commenced many years ago by the Revenue Departments of the various local Governments. Each Government naturally established the system which was thought at the time best suited to local conditions and requirements. The disadvantages became more and more evident from year to year, and at length the Government of India in 1890, after a careful consideration of the question, ordered the following changes to be made in order to secure the uniformity of system that appeared to be desirable :—

1. That a common hour for rainfall registration, viz. 8 a.m., and a common rainfall week, ending on Saturday 8 a.m., should be adopted throughout the whole of India.
2. That all rain gauges should be systematically inspected, and that copies of all inspection reports by local officers should be sent to the Meteorological Reporter to the Government of India for his information, and in order that he may make, when desirable, suggestions for the improvement of any rain gauge station at which the arrangements are not satisfactory.
3. That 5 inch Symons' rain gauges, tested by the Meteorological Department, should be the only description of gauge used.
4. That monthly returns of rainfall should be published by each local Government, of which copies shall be bound together and issued as an annual volume by the Imperial Meteorological Department.
5. That the Imperial Meteorological Department should adopt a fixed division of the year into four periods, corresponding with the periods of general rainfall throughout the year in India, for purposes of comparison.
6. That for the purpose of calculating the number of rainy days a fall of one tenth of an inch and upwards should be taken to denote a rainy day.

These changes came into operation January 1st, 1891, and the volumes for 1891 and 1892 have now been published.

Daily Weather Charts of the Indian Monsoon Area.—The Government of India has sanctioned the publication for a period of two years of *Daily Weather Reports and Charts of the Indian Monsoon Area* with a view to elucidate, if possible, the relations between the larger meteorological changes in the Indian land area and the adjacent sea areas, and more especially the conditions preceding the generation of cyclonic storms and the conditions determining the larger advances of South-west Monsoon winds in the Indian seas, and the variations in the strength of the Monsoon currents so far as they are dependent upon conditions in the sea areas.

All ships that enter the ports of Bombay and Calcutta are visited by clerks of the Bombay and Calcutta Meteorological Offices in order to make extracts of the meteorological information in the logs of the vessels, when permitted by the ship's masters. They also, when allowed, make comparisons of the ships' barometers with portable secondary standards. This information is regularly collected and tabulated, and is the basis of the data given in the Daily Weather Reports and Charts of the Indian Monsoon Area which have been prepared and issued by the Simla Meteorological Office since January 1st, 1893.

These daily weather reports may to some extent be considered as supplementary to the India *Daily Weather Reports* published by that office.

Climate of Mashonaland.—Mr. R. M. W. Shaw, a member of the Archæological Exploration Party of Central Africa, in a paper, read before the Philosophical Society of Glasgow, on the "Geography of Mashonaland," says:—The meteorology of the high plateau is interesting and extraordinary. Over the dry Kalahari Desert we experienced many electric storms; in fact almost every evening there were brilliant displays of summer lightning. At Zimbabwe I took continuous readings of the dry and wet bulb thermometers and of the barometer for the two months of June and July, and these give us a fair idea of the climate at that time. During the first week we had South-easterly winds, a high barometer, and

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rain and mists. The wind then fell, and the barometer with it, and we had three weeks of fine calm weather. The barometer reached its minimum on June 27th, and at the same time the difference of the readings of the dry and wet bulb thermometers was at its maximum—that is to say, the air was driest with a low barometer. The sky was then clear with light North winds, which were evidently local in origin, and the temperature at night fell below freezing point, so that in the morning we saw a light deposit of hoar frost. Immediately after this the barometer began to rise, there were light South-easterly winds, the atmosphere became moister, and on July 4th the South-easterly winds had increased considerably in strength, and some rain fell. From this time until August 2nd the barometer slowly rose and fell, its range being limited to three-tenths of an inch, and whenever the South-easterly winds blew at all strongly the barometer rose, and we had mist and rain.

At first sight it seems surprising that we should have windy wet weather with a high barometer, but we must remember that the only winds which can bring rain to Zimbabwe, at least in winter, are the South-easterly winds, and these, like all winds blowing towards the Equator, increase the atmospheric pressure. Zimbabwe is situated on the edge of a plateau about 3,400 feet above sea-level. The country breaks down gradually towards the south and east, and more rapidly towards the west; while towards the north it rises gently until, after about 100 miles, it attains an altitude of 5,000 feet. The West winds, if they do blow, have to traverse the continent and high country, about the sources of the Limpopo, before they reach Zimbabwe, and the Northerly winds would tend to increase in temperature after falling from the high country towards the north; so that neither of these winds will deposit moisture at Zimbabwe under ordinary circumstances. The predominant winds in this latitude are the South-easterly Trades, and they, carrying their moisture from the Indian Ocean, are forced to rise as they pass over this country, and they consequently expand and are lowered in temperature, and so deposit much of their moisture on this edge of the high plateau. A similar winter climate seems to prevail in most parts of Mashonaland, the edges of the plateau receiving most of the moisture. Manica is situated much nearer the sea than Zimbabwe, and the country there falls much more rapidly towards the east, and consequently the rainfall there is heavier. Fort Salisbury is better situated for a dry winter, for it is in the middle of a high plateau, and the South-easterly winds will have parted with most of their surplus moisture for that altitude before they reach it.

Gale in the Bahamas, Oct. 9-11, 1893.—Mr. A. Shea, the Governor, Nassau, in a despatch to the Colonial Office, states:—These Islands have been visited by a severe storm, and though the damage is less than had been apprehended, a considerable amount will be required to repair the injury to wharves and other public property.

The barometer showed signs of disturbance on Monday, October 9th, the wind having backed from North-east to North, increasing to force 7. On Tuesday the wind was North-north-west, force 8, barometer 29·86 ins. at 4 p.m. The glass then fell gradually until the afternoon of Wednesday the 11th, reaching its lowest point, 29·46 ins., at 6 p.m., when the force of the wind was 8 to 10. The wind had then veered to West-north-west with heavy squalls until it settled to South-west. During the night of Wednesday the glass rose gradually, and the following morning the weather cleared up.

The sea is said to have been the heaviest ever known here, and the wharves and other waterside private property are a good deal injured. The dwelling of the Assistant Lighthouse Keeper on Hog Island at the entrance to this harbour was washed into the sea, the inmates having but a few minutes before quitted it for shelter in the keeper's house. The latter seemed in such imminent danger that a crew from the Imperial Lighthouse tender *Richmond* manned a boat at considerable risk, and effected the rescue of both families. Mr. Stephen Albert Dillet, the second officer, was in charge of the boat, and this is the second occasion since my arrival here on which this officer performed gallant and highly meritorious service of the same character.

The accounts from the out islands that have so far come to hand report more or less damage from the heavy sea, but nothing serious from the wind. I have not yet heard from Abaco, where I fear the gale was most felt, as was the case in the August storm (see *Quarterly Journal*, Vol. XIX. p. 260).

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Climate of New Zealand.—Sir James Hector, in the *New Zealand Official Year Book* for 1893, gives an account of the climate of the Colony. He states that the climate resembles that of Great Britain, but is more equable, the extremes of daily temperature varying throughout the year by an average of 20° only, whilst London is 7° colder than the North, and 4° colder than the Middle, Island of New Zealand. The mean annual temperature of the North Island is 57°, and of the Middle Island 52°; that of London and New York being 51°. The mean annual temperature of the different seasons for the whole colony is: spring, 55°; summer, 63°; autumn, 57°; and winter, 48°. The climate on the west coast is more equable than on the east, the difference between the average summer and winter temperatures in the north-west portion of the North Island being nearly 4° less than in the South-east, while as between the corresponding portions of the South Island the differences vary by some 7°. This is due to the action of the equatorial winds, which impinge on the west coast. The extent of their influence can be better appreciated by comparing the annual fluctuations of temperature on the opposite sea-boards of the Middle Island. At Christchurch on the east, the range is greater by 7° than at Hokitika on the west.

The northern part of New Zealand is within the influence of the subtropical winter rainfall, the probability of rainfall in winter in that part of the colony being twice as large as in summer. In the south, however, the rainfall, though irregular, is distributed more equally over the year. The chief difference to be observed is that on the west coast spring rains prevail, and on the east coast summer rains, while in the middle of the colony the driest season is autumn, and in the south it is winter and spring. The contrast between the east and west coasts in the matter of rainfall is as striking as the difference in temperature. Thus in the North Island, Napier on the east has only half the amount of rain that falls in Taranaki on the west. But the Middle Island with its longitudinal range of lofty mountains exhibits this feature in a still more marked manner, for the rainfall on the west is nearly five times that on the east. The excess of precipitation on the coast is clearly illustrated by the distribution of the glaciers on the opposite sides of the range. Those on the west slope have an excessive supply of snow and descend to a line where the mean annual temperature is 50°, while on the east slope they descend only to the mean annual temperature of 37°. The winter snow line of the Southern Alps on the east side is 3,000 feet, and that on the west side 3,700 feet.

Periods of lasting drought are almost unknown in New Zealand, and only in two instances do the records show a whole month at any station without rain.

The configuration of the colony—its great length from north to south, compared with its breadth, its extent of coast line, and the division of the two principal parts by Cook Strait—renders it very subject to the influence of sea breezes. As a consequence, in parts of the country there is at times much motion in the atmosphere, and windy days are prevalent. Owing to the fact that most atmospheric disturbances pass from west to east with the centre of the depression to the south of New Zealand, there is a marked prevalence of Westerly winds throughout all seasons, but they are much modified by the form of the land. When the centre passes to the north of New Zealand, the result is that the North-east winds impinge on the east coast, bringing rain, followed by cold South-easters with heavy storms of rain and snow during winter in the south. The more common Westerly winds begin in the north-north-west with heavy rain on the west coast, and gradually veer to South-west, when fair bright weather sets in on that coast; but the same Southerly wind, sweeping along the east side of the islands, brings heavy strong weather locally known as "Southerly bursters," which from the shape of the coast reach the region of Cook Strait as South-east storms. All the other winds are either land or sea draughts, with light fine weather, or are moderate winds produced by the circulation of the atmosphere round anticyclonic areas of high barometric pressure, which are far more persistent in their influence than the fast moving cyclonic or low pressure areas. Wellington, by reason of its position near the narrowest part of Cook Strait, is peculiarly subject to wind.

Thunderstorms are most frequent where the changes of wind are most suddenly felt, from the most equatorial currents to the cold polar currents of the

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South-west. On the west coast they are most frequent in spring, except in the extreme south-west of Otago, where during winter thunderstorms are of almost daily occurrence.

RECENT PUBLICATIONS.

American Meteorological Journal. A Monthly Review of Meteorology. October-December, 1893. Vol. X. Nos. 6-8. 8vo.

The principal articles are:—The Seiche in America: by E. A. Perkins (12 pp.). The Seiche is defined as being a movement of the water rhythmical, isochronous, and of decreasing amplitude, the result of a disturbance in the atmosphere.—The hailstorm of May 20th, 1893; by Prof. F. W. Very (11 pp.). This is an account of the thunder and hail storms which occurred in South Eastern Ohio, South Western Pennsylvania, and the northern part of West Virginia. In many places the hail stones were more than 2 inches in diameter, and caused a great amount of destruction.—Analysis of the causes of rainfall, with special relation to surface conditions: by G. E. Curtis (8 pp.).—The highest meteorological station in the world: by A. L. Rotch (6 pp.). This station, which is 16,650 feet above sea-level, is situated on Mt. Charchani, Peru, and is just below the permanent snow line. It is proposed to place there a set of self-recording instruments.—A loop in the track of an ocean storm: by E. Everett (6 pp.).—The mechanism of a tornado: by Prof. H. A. Hazen (4 pp.).—Hot winds in Texas: by A. Buell (4 pp.).—Mountains as storm breeders: by R. de C. Ward (3 pp.).—The winds of the Indian Ocean: by Prof. W. M. Davis (11 pp.).—South American Meteorology: by Prof. W. H. Pickering (4 pp.).—A South American tornado: by W. G. Davies (4 pp.). This is an account of the tornado which occurred on November 13th, 1891, and devastated the village of Arroyo Seco, situated on the railroad from Buenos Ayres to Rosario. In regard to the pressure and velocity of the wind, an approximate idea may be formed by the force required to throw down buildings and to raise and carry away railroad cars. Of the 21 box and flat cars standing upon the line and sidings, 17 were upset, some with their wheels in the air, others broken in pieces, and one loaded car, having a total weight of 14,000 kilogrammes, was thrown 80 metres to the west of the road. The freight shed measuring 26 by 10 metres, constructed of galvanised iron, was raised from its foundation, and turning over in the air was thrown against the station. Some of the plates of this building were found at Isla del Rio, a distance of over two miles. A most extraordinary feature was that the front wall of the station which received the blow of the shed suffered little damage, while the opposite wall, 50 centimetres thick, was so bent that it had to be rebuilt, and the interior partitions, 20 centimetres thick, were for the most part entirely thrown down. This phenomenon can only be explained by the difference in atmospheric pressure between the inside and outside of the building due to its sudden diminution outside at the first gust of wind, so that the air confined inside acquired for the moment an explosive force. Employing all available data, it results that the force of the two wind components (vertical and horizontal) exerted a pressure of 125 lbs. per square foot, but probably for a few seconds only.—Errors of the psychrometer: by Prof. H. A. Hazen (2 pp.). This is a criticism of Mr. Midgley's paper "Constructive Errors in some Hygrometers" which appeared in the *Quarterly Journal*, Vol. XIX. p. 197.

Annuaire de la Société Météorologique de France. Tome XLI., January-June, 1893. 4to.

The principal articles are:—Problèmes relatifs à la circulation générale de l'atmosphère: par H. Lasne (19 pp.).—Résumé des observations centralisées par le Service hydrométrique du bassin de la Seine pendant l'année 1891: par M. Babinet (30 pp.).—Notice relative aux chutes de neige de Janvier 1893: par V. Raelot (1 p.).—Résumé des observations magnétiques faites en Islande, à l'île Jan Mayen et au Spitzberg, en 1892, par MM. les officiers du transport *La Manche:* par T. Moureaux (4 pp.)

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Indian Meteorological Memoirs: being occasional Discussions and Compilations of Meteorological Data relating to India and the Neighbouring Countries. Vol. IV. Part VIII. 4to. 1893.

This Part is devoted to an account by Mr. J. Eliot of the more important cold weather storms in India during the years from 1876 to 1891. From this discussion it appears that the cold weather storms are phenomena of an upper current in Northern India which forms an important part of the general circulation of the earth's atmosphere. So far as can be at present judged, they form in the plateaux and mountain areas of Upper India, Baluchistan, Persia and Afghanistan, and are hence apparently similar to the majority of the winter storms in the United States, which are said to form in the area to the west of the Rocky Mountains. It is possible the cold weather storms of India may be merely the redevelopment of shallow depressions travelling eastwards, but there is as yet little or no direct evidence in favour of this supposition. Their development and the peculiar features of the secondary depressions, and the dependent phenomena, have been explained by the relations between this upper current over Northern India and the influx of air from the equatorial belt, and by the action of the vast mass of the Himalayas and Afghan Mountains, and other geographical conditions, in modifying the cyclonic motion in India determined originally by the primaries. The phenomena of the warm waves and the dry cool waves which accompany them are to some extent of special effects determined by the conditions of the snowfall in the areas to the north-west and west of India. Their history shows the necessity for an early extension of meteorological observations in the long area between the field of European and of Indian meteorological work. It is doubtful whether it will be possible to trace the origin of these storms more definitely until international charts for the Northern Hemisphere, or at least for Europe, North Africa, and Asia, are prepared.

Meteorologische Zeitschrift. Redigirt von Dr. J. Hann und Dr. G. Hellmann. September-November, 1893. 4to.

The principal contents are: — Die Registrirungen des Moreland'schen Gewichtsbarographen von R. Fuess in Berlin: von Dr. Grossman (7 pp.). Weight barometers have never been much used in this country, the cost of King's, owing to the large quantity of mercury required, having effectually damped the ardour of intending purchasers. Dr. Grossman's paper gives us a carefully drawn up account on the advantages and disadvantages of the form of apparatus which has now acted for seven years at the Seewarte, Hamburg. The apparatus works by electricity, and Dr. Grossman admits that interruptions in registration are not uncommon.—Zur Dynamik der Atmosphäre: von M. Möller (11 pp.). This paper completes this treatise, which has been carried on for five months with intervals. At pp. 336-7 Dr. Möller gives the summary of all his conclusions.—Die klimatischen Grundgleichungen des Königreichs Sachsen: von Dr. P. Schreiber (9 pp.). This is a summary of a forthcoming paper in the third part of the *Klima von Sachsen* to appear next year.—Oliver Lodge über Blitzableiter und Blitzschutzvorrichtungen: von A. V. Obermayer (10 pp.). This is an abstract of Prof. Lodge's book, *Lightning Conductors and Lightning Guards*.—Die säkularen Temperaturschwankungen in Turin: von Dr. J. B. Rizzo (4 pp.). This is a discussion of the temperature records of Turin, which go back to the year 1753, with the view of testing the truth of Brückner's assertion that temperature follows a cycle of 35 years. Dr. Rizzo claims to have proved that his figures show a period of 19 years.—Ueber die Häufigkeit der Halo-Phänomene: von Dr. G. Hellmann (4 pp.). This paper shows that the ordinary idea that lunar halos are more common than solar ones is entirely incorrect. Dr. Hellmann maintains, from the figures he has been able to find, that solar halos are about five times as common as the lunar. Solar halos are most frequent from April to June, and least so in mid-winter. Lunar halos are most common in the winter half year. These results mainly are derived from the older observations at Upsala, and are confirmed by figures from New York and from Japan. It is much to be regretted that at most observatories no regular watch is kept on the sky, and thus many halos, &c. escape notice.

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Mittheilungen des K. K. Militär-Geographischen Institutes. Band XII. 1892. 8vo.

Contains: Vergleiche von Quecksilber-Barometern mit siede-Thermometern: von H. Hartl (75 pp.). The author, who has already written several papers in the *Meteorologische Zeitschrift*, has printed this paper in defence of boiling point thermometers, which have of late years been rather under a cloud since the introduction of aneroids. He concludes that boiling point thermometers are at least as accurate as siphon mountain barometers, provided they have been accurately tested and the tube calibrated throughout its whole length. He holds that such thermometers are absolutely indispensable for all explorers making mountain ascents.

Symons's Monthly Meteorological Magazine. Vol. XXVIII. October-December, 1893. 8vo.

The principal articles are:—The Chicago Meteorological Congress (3 pp.).—Rainfall in Persia (4 pp.).—The British Association at Nottingham (3 pp.). This includes abstracts of several of the meteorological reports and papers read at the Meeting of the Association.—Sunspots and Air Temperature (1 p.).—The Drought and Heat of 1893: by P. Bicknell (1 p.).—October Raspberries and Strawberries (1 p.).—March to October 1893 (6 pp.). This is a comparison of the 1893 observations with those for the 10 years 1883-92, and shows the remarkable character of the past season.—The Minimum in Winter on the summit of Ararat (1 p.).

Weather Lore. A Collection of Proverbs, Sayings and Rules concerning the Weather. Compiled and arranged by RICHARD INWARDS, F.R.A.S. 1893. 8vo. 200 pp. and 2 plates.

This is really the second edition of a little book which Mr. Inwards published in 1869. The present volume has been very neatly got up, and contains the most extensive and complete collection of weather lore yet published. It is accompanied by a plate illustrating the various cloud forms, together with their heights and names. It has also a bibliography of weather lore, and a very full index.

Zeitschrift der Gesellschaft für Erdkunde zu Berlin. Band XXVIII. 1893. No. 2. 8vo.

This contains a paper (30 pp.) by Dr. J. Hann on the Climate of Quito. The material which the author had at his disposal was extraordinarily scanty and sporadic; 3 months, not consecutive, between February and May 1871, and then 29 months, October 1878 to March 1881. Nothing but Dr. Hann's experience and his unremitting care in investigation could have enabled him to obtain any conclusions from such data. For instance, some of the data in the published records he dismisses as being absolutely fictitious. He finally obtains from Whymper's observations values for Guayaquil, and gives as his final result a mean value of the barometer at sea level at Guayaquil at 29·922 ins. As for temperature he finds that the old value of 60° given by Boussingault and quoted by Dove to be more than 3°·7 too high. The value Hann finds is 56°·3. In this connection Hann speaks of the value of earth temperatures at the depth of 3 feet, a method of observation which has been much neglected of late, but which in tropical countries gives an exceedingly accurate value for mean air temperature. Two separate observers at different times found respectively 56°·3 and 55°·8. A closer approximation to air temperature could hardly be expected, In conclusion, the climate of Quito is an eternal spring, and therefore equally trying to the residents as our own.

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Royal Meteorological Society.

Offices:—22 GREAT GEORGE STREET, WESTMINSTER, S.W.

SESSION 1894.

ORDINARY MEETINGS at 8 p.m.

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ANNUAL GENERAL MEETING,

January 16, 1895.

By permission of the Council of the Institution of Civil Engineers, the above Meetings will be held at 25 Great George Street, Westminster, S.W.

NOTICE.

The Library and Offices of the Society, 22 Great George Street, Westminster, are open daily from 10 a.m. to 5 p.m.; Saturdays, 10 a.m. to 2 p.m.

The Society is not responsible for the views and opinions advanced in the *Quarterly Journal*.

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1895

QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY.

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ON THE CLIMATE OF SOUTHERN CALIFORNIA.

An Address delivered to the Royal Meteorological Society, January 17th, 1894.

BY C. THEODORE WILLIAMS, M.A., M.D., F.R.C.P.

PRESIDENT.

(Plate I.)

THE subject of this, my valedictory address from the Presidential chair, is the Climate of Southern California, which, though largely studied by the Weather Bureau of the United States, is not so well known in England, and perhaps we chiefly derive our impressions of California from what the Americans call "the canning industry," which floods our stores and grocers shops with gaily coloured tins of preserved fruits and vegetables, the produce of that sunny and fertile land.

I propose, on the present occasion, to give you some account of the climate of this favoured region, gleaned during a visit in the autumn of 1892, when I investigated its present and future resources from an invalid point of view.

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My conclusions are largely based on the publications of the Weather Bureau of the United States.

The entrance into California from Utah and Nevada is a welcome event for the passenger by the Union Pacific Express. After leaving Salt Lake City, the train for long hours skirts the shores of the great Salt Lake, with its numerous rocky islands rising hazily from its blue waters, and its back ground of snow-capped mountains, and then it plunges into the great American desert, a vast tract of alkaline soil growing nothing but sage scrub (*artemisia*) and inhabited only by Jack rabbits and lizards. There is no water save that tainted by alkali, and before the railway came many a traveller, man and horse, perished there from thirst, leaving their bones to whiten on the parched soil. The monotony of the landscape is broken by the remarkable cliff-like ranges of mountains in the distance, whose weird shapes, cleft precipitously, assume the forms of Grecian temples, of columns and altars and of towers, looking vivid and near in that transparent atmosphere. We traced out the Propylæum and the Theseum of Athens, and once towards sunset a red Sunium temple stood out boldly against the lemon sky. The railway stations, where may be seen a solitary cowboy in picturesque costume, or a few Indians lank and squalid, but clothed in gay colours, are rare, and are supplied with food and water by the passing trains, and during this journey we rescued a goods train, in difficulties from running short of coal, by taking it on with us to the next siding.

After several hours of this dreary waste one hails with joy the entry into the defiles of the Sierra Nevada, and the ascent to Summit Station, the highest point (7,042 ft.), and then the descent by the lovely blue Donner lake to the Pacific coast. The air at once becomes more balmy and is laden with fragrant odour of the conifers, and the eye wanders through vistas of densely wooded hills of considerable height, intersected with gorges and valleys, looking in the distance blue and mysterious; and in the depths could be discerned a silver stream threading its way to the ocean. The woods were of various kinds of fir, some of grand size, and, as in all American forests, there stand out a number of dead giants, with rich red trunks, the rugged sentinels of the Pacific. Next we came to fine oaks and cotton trees, acacias, sumachs, and maples, all, as it was November, in their brilliant autumn colouring, the prevailing hue being yellow here, in contrast to the vivid red we had left behind in the Eastern States. The little shanty cities began to lose their barrenness, balconies wreathed with plumbago and bright with roses and scarlet geraniums told of the south, and we soon reached vineyards with grapes and figs to sell at the more frequent stopping places, and so on past Sacramento, over the broad Oakland Ferry to San Francisco and the Golden Gates.

Some days later, after leaving San Francisco at 5.30 p.m., we next morning found ourselves passing through the Mojave Desert, a large tract of country destitute of water, and at present growing only sage scrub, cactus, aloe, and that extraordinary tree the yucca palm—a species of gigantic yucca, which attains a height of 20 to 40 ft., and stretches ·nt its gaunt

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irregular arms like a ghostly *araucaria*. It appears to be the characteristic tree of the arid regions, as we found it also in the Colorado Desert and in Arizona. This Mojave Desert is not of sand, but the soil is detritus of granite, rich in felspar and mineral phosphates, and it only needs a good supply of water to render it fertile, for parts, such as Antelope Valley, have already been converted into corn fields by irrigation.

Penetrating the Tehachapi Mountains, we emerged into the rich and fertile district of Southern California, and soon reached its capital, Los Angeles.

And now let me say a few words about the topography of the region.

California, as will be seen in any map of the United States, is a narrow strip of territory fringing the Pacific for nearly 1,000 miles, and extending over 10° of latitude, from 32° 30′ to 42° N.

Two ranges of mountains traverse the State from north-west to south-east, the western or coast range consisting of a series of low mountains running more or less parallel to the shore, and intersected by numerous valleys. The eastern range, the lofty chain of the Sierra Nevada, rises to over 13,000 ft., and is snow clad in parts, presenting almost an unbroken barrier to the east, for, according to Dr. Orme, of Los Angeles, "for nearly a thousand miles there is no pass lower than 5,000 ft. in height save where the Sacramento, Klamath, and Columbia Rivers have worn deep gorges through its rocky fastnesses."

Towards the south of the State the Tehachapi Mountains rise out of the St. Joaquin Plain and running east and west join the Coast and Sierra Nevada ranges, and south of this chain lies the territory of South California. This, as the map shows, forms an irregular parallelogram lying between 32°·30′ and 35°·40′ N lat., bounded on the east by the States of Nevada and Arizona, being separated from the last by the River Colorado after it has emerged from the grand Cañon and is on its way to the Gulf of California; on the south by New Mexico; on the north by the Tehachapi Mountains; and on the west by the Pacific. There is an irregular coast line sloping towards the south-east of about 330 miles, though the length of this district in a bee line is 230 miles. Its breadth is 330 miles.

From the Coast and Sierra Nevada chains run sundry lesser ranges, chiefly east and west, such as the Santa Ynes, the Sierra Pelona, the San Gabriel, and the San Bernardino, which rises in Old Grayback, to a height of 11,725 ft.

Southern California is divided into six counties, which starting from the north, are Santa Barbara, Ventura, Los Angeles, San Bernardino, Riverside, and San Diego, the most southerly.

The mountain shelter from the north and east may be described as tolerably complete, and the protected area consists of (1) valleys, chiefly running into the coast range from the sea, and rising to various elevations, such as the fertile San Fernando and San Gabriel Valleys, or else (2) more or less extensive plains, as those of Santa Ana and San Jacinto.

Southern California may be subdivided into two portions, eastern and

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western, by the Sierra Nevada and its spurs, the San Gabriel and San Bernardino mountains.

The eastern portion consists of an arid region, called the Mojave and Colorado deserts, separated from each other by a low ridge of hills. This forms part of the great Basin, and the few streams which flow from the eastern side of the Sierra Nevada enter the Colorado river or lose themselves in the sink of the desert—most of the drainage flows to the Pacific.

The greater part of this desert tract, stands from 1,000 to 3,000 ft. above sea level, but there exist some great depressions, such as the Death Valley and the Sink of San Felipe, which are more than 100 ft. below the sea level and are supposed to have at one time formed part of the Gulf of California, but to have been separated from it later by a geological upheaval.

I do not propose to dwell much on the climate of the eastern portion of South California, but shall occasionally use it as a contrast to the climate of the western portion, and to demonstrate, how in the same latitude, and to a great extent with the same geological formations, the important conditions of ocean currents and shelter from cold winds, with a good supply of water, will convert a desert into a fruitful garden.

The climate of the *eastern* region is very dry, very hot in summer, and moderate in winter, and may be judged of by the returns of Fort Yuma at the extreme south of the Colorado Desert, where the mean temperature of the months of June, July, and August was 87°·1, and that of December, January, and February 54°·8. The average annual rainfall is 2·1 ins. At four stations in the Mojave Desert, Camp Cady, Barstow, Dogget and Fenney, the same state of things prevailed, the annual rainfall varying from 1 to 2 ins., and the summer heat being extreme; but this reaches its climax in the Death Valley, situate 175 ft. below sea level, where both heat and aridity are increased by the valley being narrow and deep, and enclosed by high and bare mountains. This has been reported to be the hottest place in the world. The valley derives its name from an unfortunate party of emigrants who in 1850 perished from thirst while attempting to cross it. It is 75 miles long and from 12 to 20 miles broad, and has been surveyed by various expeditions of the U.S. Government, and in 1891 a party encamped in the valley from May to September to study the summer conditions, and a report was issued by Prof. Mark W. Harrington, the present head of the Weather Bureau.

The temperature during the five months rarely fell below 70° and gave an average of 94°. It occasionally rose to 122° in the shade, and it has been stated by Mr. Spears to have once reached 137°. It is not only hot in summer, but consistently hot, and the heat is increased by burning blasts from the desert. The air was not stagnant, but in active motion. Heat and movement of the air together make the valley very dry and the relative humidity low. The range of temperature is nevertheless considerable, amounting to 23°. Men are reported to have been driven insane while trying to cross the valley, and a borax collector (there are large deposits of that product there) died suddenly with the water canteen in his hand. No men or beasts cross the valley now, save at night; and meat slaughtered

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at night and cooked is spoilt in the morning; but if cut thin and soaked in brine it is cured in the sun in one hour. The maximum is higher than any figures noted in the Sahara, and is only equalled by the values for one station in India, Jacobabad in the Punjab.

The climate of the *western* portion of South California has three important factors.

1. Its southern latitude, which corresponds to that of the Empire of Morocco or of the French Province of Algiers in Africa.

2. The influence of the Pacific Ocean, and especially of the Kuro Siwo current, or Black Stream of the Japanese Seas. This current exercises the same warming and equalising influence on the Pacific coast of North America, as the Gulf Stream does on our western coasts and those of Norway, and, as Mr. Scott says, "it is to this stream that Sitka and the coasts of British Columbia owe their immunity from the ice which besets the shores of Asia in corresponding latitudes." A glance at any map of isotherms will show the effect of this current on the isothermal lines of North America in January and July, in the former case raising the temperature of the Pacific shores far above that of inland regions, and in July moderating the summer heat, and thus reducing the temperature. Very markedly so is this influence felt in the western part of Southern California, which at no point lies more than 60 miles from the Pacific and is largely open to its influence. The temperature of the water of the Pacific rarely falls below 60°, or rises above 70°.

3. The influence of mountain ranges. One effect is undoubtedly protection from Northerly and Easterly blasts which the double range of mountains renders very complete. The other effect is the condensation of moisture from the vapour-laden winds blowing from the Pacific. This accounts for the increased rainfall of this region, though this is less than that of Northern California. The existence of the Mojave and Colorado deserts may be due to their lying, like the American desert, to the leeward of the mountains, and thus being shut off from the influence of moist winds.

We may now consider the principal features of the climate of this region.

According to Dr. Orme, to whom I am largely indebted for information, both from his works and his conversations with me, the rainfall is about 16 ins. a year, the annual amount varying greatly as to year and locality, and contrasting strongly with that of the eastern basin, noted at Fort Yuma, as the subjoined table will show.[1]

ANNUAL RAINFALL.

	Ins.
Santa Barbara, northern coast	16·92
Los Angeles, 16 miles inland	17·95
San Bernardino, 60 miles inland	16·85
Fort Yuma, Colorado Desert	2·10

[1] Orme. *Climate of Southern California.*

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The distribution of the rainfall during the decade from 1881-1890[1] for three stations, Los Angeles (inland), San Diego (coast), and Riverside (60 miles inland) show great irregularity, but altogether a moderate amount.

Years.	Los Angeles.	San Diego.	River-side.
	Ins.	Ins.	Ins.
1881	5·53	5·00	3·95
1882	10·74	9·24	5·78
1883	14·14	8·01	5·58
1884	40·39	26·95	25·32
1885	10·69	5·72	5·15
1886	17·22	15·39	8·02
1887	16·07	10·72	7·81
1888	21·04	11·57	15·48
1889	33·31	16·03	20·41
1890	12·49	8·2	11·53
Mean	18·16	11·62	10·90

The mean relative humidity on the coast varies from 69 to 75 per cent. in the winter months, and from 60 to 68 per cent. in the summer. The annual mean percentage (11 years) for San Diego (coast) is 74·7, that for Los Angeles (inland) 69 per cent., while in summer it falls at Fort Yuma to 35 per cent.

The rainfall is distributed over the months of October to April, and in January there may be as many as five rainy days successively. Los Angeles counts about 42 days in which an appreciable amount of rain falls, and San Diego 41 days, Riverside 40 days. The sun shines on an average on 300 days out of the year, and for 179 days without a cloud, but there are 47 cloudy days, and on the so-called fair days fogs and mists are occasionally noted; indeed a bad feature of this climate are the mists which come up suddenly from the Pacific and envelope everything in a cold damp atmosphere. One hot sunshiny day I was standing in the Lake Park of Los Angeles, looking at the fine view of the Sierra Madre Mountains, when suddenly I was enveloped in a thick cold mist, which shrouded the whole scene and made me shiver. Two days later at Santa Barbara the phenomenon was repeated. It was a blazing hot day, and we were inspecting Santa Barbara from the train, or cars as they say in America, when suddenly a chilly feeling came over us and Santa Barbara disappeared in fog. This only lasted for a few minutes, the sea-mist as it passed moving further inland. These mists do not appear to deposit much moisture, but are bitterly cold. They always come from the Pacific, but are stated to be limited to the lower ground, and never to rise above 1,000 ft.

The mild temperature and the relative equability of Southern California are its great attraction, and its climate has been spoken of as one of perpetual spring, but the figures, and certainly my impressions in November, rather

[1] Davidson. *The Climate of South California.*

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indicate a climate of perpetual summer. The mean temperature of Los Angeles and Riverside for 1890 was 68°, for San Diego 62°·6, and for Santa Barbara 60°·2.

The monthly means for 11 years at Los Angeles, San Diego and Santa Barbara are given below and show remarkable equability.

Months.	Los Angeles.	San Diego.	Santa Barbara.
	°	°	°
January..	52·5	52·8	52·5
February	54·3	54·3	54·7
March ..	56·3	56·0	55·9
April	59·0	58·6	58·6
May	62·2	61·3	59·6
June	66·0	64·4	62·9
July	69·2	67·2	65·9
August ..	70·2	69·1	67·0
September	68·4	67·2	66·6
October..	63·1	62·6	62·9
November	59·0	58·5	59·4
December	55·7	56·5	55·8
Year ..	61·3	60·7	60·1

The highest temperature recorded at Los Angeles was 105°, and the lowest 28°, but at San Diego the corresponding figures were 101° and 32°, a difference due possibly to its situation on the coast.

Frost is of very rare occurrence, except on some of the low lying marshy grounds, or again high up on the mountain slopes. Indeed with the multitude of subtropical crops, the effects of frost are soon visible and fearfully destructive, as has been seen, though fortunately seldom at Riverside. The heat in summer is occasionally great, but not excessive as in the neighbouring desert; and beyond "camping out," which is a great delight to Californians, many never go to any distance from their homes.

At Fort Yuma, our standard of comparison, during the year 1880 the temperature exceeded 100° for 78 days, on 28 of these the mercury rose to 110° and higher.

As I have before said these temperatures are well borne in the exceedingly dry atmosphere and work is carried on as usual; sunstroke is unknown.

While the difference between monthly means is small, there is occasionally considerable range between the maxima and minima, as in 1890, when the range was 71° at Los Angeles, 68° at San Diego, and 64°·5 at Santa Barbara.

The winds according to Dr. Orme during the summer have the prevailing directions from the North and North-west, and in winter from the South and South-west, and are generally of a refreshing character, but taken as a whole the winds are Westerly.

There are certain local winds, and among them the Norther, Chinook, or Santa Ana as it is called in Southern California, a remarkably dry current generally local in its prevalence, but occasionally making itself felt over large districts. While it blows the air becomes highly electrified, horses tails stand

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out like thick bushes, the hair crackles when stroked, and metallic objects duly insulated give forth electric sparks if a conductor is brought near. Nevertheless the Santa Ana wind is reported to be followed by a specially pure and invigorating atmosphere.

It will be seen that the climate of South California is a warm, temperate, and on the whole an equable one, with more moisture than that of Colorado, the subject of my last year's address, and a climate which would allow of much out-door life all the year round.

We will next consider its effect on vegetation and take a glance at the results of diligent watering and gardening in this beautiful region.

Our first excursion from Los Angeles was to Santa Barbara on the coast, at the northern extremity of South California, though with a due southerly aspect. After 4½ hours by rail through a rich plain in which oranges, figs, plums, and grapes are produced in great abundance, we came to the Pacific at Ventura and ran along it into Santa Barbara, a flourishing little town of 6,000 inhabitants, embosomed in orange and lemon groves backed by hills covered with vineyards, and protected to the north and east by the Santa Ynes range.

The vineyards of Santa Barbara are of comparatively ancient date, as they were planted by the Franciscan monks, who introduced the culture of the vine and of the olive in 1769, and did much to civilise and christianise the native Indians. The Spanish Fathers established missions at Santa Barbara, Santa Monica, San Diego, San Gabriel, and other places, erected graceful churches and conventual buildings, and fortunately named the places in which they settled in the beautiful Spanish language, and thus stamped the country with a picturesqueness which the modern American could not have supplied. Their buildings, made of the baked clay or adobe of the neighbourhood, are always simple and in good taste, and show how much beauty of form can be obtained with poor material, while the ruins, clothed with the semi-tropical luxuriance of nature, delight the eye.

Santa Barbara has a port with a wooden pier, and has abundance of street cars, electric and others, and some fair hotels, besides plenty of villas in gardens, and ranches in the neighbourhood which are the best places for invalids. It is a famous place for flowers, and a floral festival is held in April, when there are processions of flower-bedecked carriages and cars like the *bataille des fleurs* at Cannes and Nice. The roses grow in great profusion, and the arum, called by the Californians the calla lily, is largely cultivated and the bulbs exported for the eastern market. It would be impossible for me to go into the subject of floriculture, but the land is apparently able to produce any flowers, though as fruit is so profitable, this department is at present kept in the background.

Along the coast we come to Santa Monica and San Pedro, both centres of rich luxuriance of vegetation, and gay little Redondo Beach, and then by the surf line we reach Ocean Side, another modern sea-side place. Near this spot I witnessed the most gorgeous sunset I have ever beheld. I have seen beautiful sunsets in Italy, Sicily, Greece and Spain. I have seen northern ones of great splendour, but anything to equal this Pacific one I do not

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remember. The sun sank into a deep green ocean lit up with golden light, which imparted a remarkable transparency, as of liquid flame. Above was a sky red as a furnace, out of which rose like incandescent masses the picturesque islands of Santa Catalina and San Clemente. The red gradually faded into the usual pearly sunset tints, but the ocean retained for a considerable period its wonderful green hue. The weather was fine and warm, 88° to 84° in the shade, and there had been no rain for months.

The next place of importance, with its magnificent harbour, is San Diego, the second port of California, situated close to the frontier and within full view of the Mexican mountains, which at Coronado are only 12 miles distant.

San Diego was the first mission of the Franciscan Fathers, and is now a flourishing town of 16,000 inhabitants of the usual American type. San Diego County, probably because of its southern position, has been found to be specially suitable for the growth of the lemon, and in addition to the lemon groves now established, it is proposed to bring, by means of irrigation, 150,000 acres of "frostless" ground into cultivation for this tree, by means of gigantic dams, such as the Hemet, Sweetwater and others. The San Diegians calculate on being able to irrigate 250,000 acres in time. However, my object was less to see San Diego itself than Coronado Beach and its famous hotel. This we reached by crossing the harbour to the narrow spit of sandy land which separates it from the ocean. We landed from our steam ferry and were taken to the hotel by a steam tram through a garden abounding in exotics, and, curious contrast in this frequented spot, there was plenty of wild life, for outside the botanical garden, as it is called, are numerous Jack rabbits and cotton tails (ordinary rabbits), while on the shore shooting of canvas-backed ducks was going on.

The hotel is built in irregular lines, and stands at a short distance from the beach, commanding fine views in all directions to Point Loma and to the town and harbour of San Diego, backed by the San Jacinto and San Bernardino ranges, and the Mexican Table Mountain. There is a fine expanse of the Pacific, rising out of which are the small Coronado Islands which belong to Mexico.

The hotel is a picturesque building which covers 7 acres and is entirely built of wood. It contains 1,200 beds and a considerable number of public and private sitting rooms, and is surrounded by terraces both open and covered; there is also a large quadrangle sheltered from all wind but open to the sun and planted as a garden. Here grow many beautiful exotics, the guava tree, the scarlet hibiscus, the rosa sinensis, the stephanotis, the loquat or Japanese medlar, and the persimmon; many varieties of palms, such as the Seaforthia, which we admire in the large hothouse at Kew, the coco plumosa, the Washingtonia philaferia, the Kentia, and the oreodoxa or Royal palm. The Bougainvillea, as everywhere in South California, covers the walls with gorgeous sheets of colour, and the heliotrope scents the air. Lastly, the scarlet poinsettias attain to the size of trees, and reminded me of those I had seen growing in the Latomia of Syracuse in Sicily.

Coronado Beach has good salt baths, and from what Dr. Raphael Lorini,

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the resident medical man, told me it is largely patronised in the winter by people from the Eastern States, especially Bostonians, who suffer from the exhaustion of city life. The temperature, even in the middle of November, was here, as generally during my sojourn in South California, 88° to 84° in the shade for the midday hours, and the evenings cool and refreshing, the air dry and clear.

Among the attractions of Coronado is an ostrich farm, similar to those at Santa Monica and Santa Barbara. The birds are often vicious and have kicked some of their attendants to death, but the experiment of ostrich breeding is interesting and promises to succeed.

The whole inland district from the Pacific Coast to the San Gabriel and San Bernardino mountains, and far up the slopes of these ranges, is cultivated and for the most part irrigated, as we saw on our return to Los Angeles from Coronado Beach. The principal inland towns in addition to the capital are Santa Ana, Colton, Riverside, Pomona, San Bernardino, all prosperous centres of fruit, flower and vegetable growth, and with plenty of railway communication, for no less than ten lines radiate from Los Angeles in all directions. Los Angeles is a well-built city of some 60,000 inhabitants and stands about 300 feet above sea level, commanding a fine view of the Sierra Madre mountains.

The charms of the place are its numerous parks or public gardens tastefully laid out with palms, pepper trees, magnolias and other beautiful trees and shrubs, as well as with gay flower beds. The streets are chiefly paved with asphalt and of course pervaded by the eternal cable and electric cars, the houses are handsome and many are surrounded with gardens, so that the effect is pleasing. Having already sketched the chief features of the climate I shall only add that the hotel accommodation at Los Angeles is fairly good and that there is an interesting and instructive museum of all the productions of South California, vegetable and mineral.

The desirable winter residence is Pasadena, 8 miles to the north of Los Angeles in the San Gabriel valley, on the slopes of the Sierra Madre and in the midst of orange groves, with magnificent avenues of pepper trees and specially well tended gardens. This small town of 12,000 inhabitants, 900 ft. above sea level, will be shortly connected by a log wheel railway with the summit of Mount Lowe, 7,000 ft., one of the Sierra Madre heights, which is snow capped in winter; and thus the Californians will be able to tramp through the snow on Mount Lowe and after 30 minutes railway descent to pick roses at Pasadena.

The view from the Raymond Hotel is extensive and beautiful; one gazes over a vast garden bordered by the Pacific, of which a glimpse is obtained at San Pedro, to the north rise the Sierra Madre and behind these Old Baldy, one of the San Bernardino range, rising to 10,142 ft. and tipped with eternal snow.

We contemplate a wonderful mass of luxuriance at our feet, orange and lemon trees, the older ones larger than those of Southern Europe, loquats, Japanese persimmons, loaded with ripe fruit, olives and palms, as well as the

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ever present eucalyptus, mingled with cherries, apricots, peach, and nectarine standards, and then to think that 20 years ago all this was a sheep pasture with a lonely ranch which irrigation, in this fine climate has converted into a Garden of Eden.

Further east on the slopes of the same range lies a charming hotel called the Villa Sierra Madre, embosomed in olives and oranges, 1,800 ft. above sea level, with 100 beds and all arrangements for invalid residence. Here I was hospitably entertained by my friend and patient Dr. Gresham, late of Bromley, and spent an agreeable day in exploring the district. From thence to the San Bernardino Pass is a series of gardens which flourish apparently in proportion to the amount of irrigation. This is carried on either by leats, *i.e.* by conducting mountain streams in channels or by tunnelling into the mountains for water, or, in the lower grounds, by sinking artesian wells.

It is remarkable that in this warm climate that with so much water artificially spread over the land, there appear to be no malarial fevers.

Riverside (population 4,683) lies in the plain, away from the mountains, and has the reputation of being the best irrigated and cultivated tract of the whole region. The yield in oranges in 1890 was 858,841 boxes, the varieties grown being chiefly the Australian navel orange and the seedless Washingtons. Vines are grown for raisins; raisin exportation appears to be more profitable here, wine is made in other parts of South California. Riverside possesses its famous magnolia avenue 12 miles long and 125 ft. wide, lined with exotics, with the orange groves on each side.

Besides the fruits already mentioned, Southern California produces such subtropical ones as the cherimoyer or custard apple, the pineapple, the banana, and among our English fruits strawberries all the year round, raspberries, blackberries, currants, mulberries, quinces, apples, pears, cherries, and figs, the only difference being that the seasons of most fruits are longer there than here. Pumpkins and melons of all kinds abound.

Wheat yields an abundant crop, and has averaged on some large ranches a harvest of 1 ton to the acre, but 1,800 lbs. is considered a satisfactory yield. Barley also is largely grown in the southern part of the State, and more than a million sacks are produced yearly. This and wheat are grown without irrigation.

Alfalfa, or lucerne, generally requires artificial water supply, but with this will give from 3 to 6 crops a year, with an average of 1 to 2 tons to the acre for each crop.

In Ventura County beans are the staple commodity, and elsewhere beet is cultivated and sugar made from it.

Lastly, another large branch of industry are the bee farms, the product of which we see in the Californian honey, the special flavour being due to the bees feeding on white sage.

So much for the effect of the climate on vegetation.

Man appears very healthy and happy. The death rate of Los Angeles is 12 per 1,000, a very low one, though it contains a large proportion of deaths from consumption, owing to the number of invalids who flock to this

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country. I have known several who have done well; but to attain satisfactory results patients must not visit it for a winter and then return eastward, but should make it their home, and if possible take to some occupation involving an open air life, like gardening or fruit farming, returning to less complex conditions than those of city life. Many who have done so have greatly prospered in health and pocket.

In conclusion, the climate of Southern California seems to be characterised by

1. A warm sunny atmosphere all the year round, permitting much outdoor life and camping out in summer.
2. Remarkable equability of temperature, daily, monthly, and annual.
3. Abundance of sunshine at all seasons of the year.
4. A moderate rainfall and a small number of rainy days, occurring chiefly in winter and spring.
5. A fair relative humidity percentage, evenly distributed over the whole year.
6. The prevalence of fog, or sea mist, from time to time rolling in from the Pacific Ocean, but not reaching the higher lands.
7. A porous soil, which when supplied with abundant water by American energy, seems capable of producing extraordinary crops of grains, fruit, and vegetables.

REPORT OF THE COUNCIL

FOR THE YEAR 1893.

In presenting their Report, the Council have to congratulate the Society on its steady and uninterrupted progress during the past year. There is an increase in the number of Fellows elected over the number elected in 1892, and the balance at the Society's Bankers at the end of the year is larger than the balance brought forward from 1892.

The Council feel that the Society will regret the numerous losses by death sustained during the year, and particularly those of Lord Ebury, Thomas Hawksley, William John Harris, George Matthews Whipple, and Henry Francis Blanford.

The death of Lord Ebury, on November 18th, removes one of the small band, still remaining, of those who took part in promoting the foundation of the British Meteorological Society. Lord Ebury, then Lord Robert Grosvenor, was, in 1838, a Member of the Council of the original Meteorological Society of London. At the Anniversary Meeting of March 12th, 1839, he was elected its President, and continued to hold that office until the Society was dissolved, on August 14th, 1850. The British (now the Royal) Meteorological Society was founded on April 3rd, 1850, and Lord

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Ebury joined it on May 7th following. He was then elected one of its Vice-Presidents, a position which he occupied until May 27th, 1856. From this date he occasionally attended its meetings, and ever showed an interest in its welfare.

The late Thomas Hawksley, F.R.S., Past President of the Institution of Civil Engineers, joined the Society on January 22nd, 1856, and during his long career as one of the most distinguished Civil Engineers was always a keen supporter of the science of Meteorology.

The late William John Harris, M.R.C.S., of Worthing, joined the Society on November 20th, 1867, and served on the Council for 1875. He will be chiefly remembered as being the Society's observer at Worthing, where he commenced his records in 1867, and continued them till his death on August 28th, 1893, a period of over 26 years. These observations, through the great courtesy of Mrs. Harris, are now being continued by Mr. G. B. Collet.

The late George Matthews Whipple, B.Sc., F.R.A.S., joined the Society on April 15th, 1874, and was a most energetic worker. He was employed at the Kew Observatory from October 1858, and held the post of Superintendent from 1876 until his death. He served on the Council from 1876 to 1887, and contributed no fewer than 22 papers to the *Quarterly Journal*. He died at his residence at Richmond on February 8th, 1893.

The late Henry Francis Blanford, F.R.S., F.G.S., who had achieved a high reputation as Meteorological Reporter to the Government of India, joined the Society on November 20th, 1878, served on the Council from 1888 to 1891, and he did good work as a member of the Editing Committee. He died at Folkestone on January 23rd, 1893.

The loss of such men, together with the other serious losses by death mentioned later on, have left a great void, which it will be difficult to fill.

Of those who were either Founders (marked *) or were elected in the first year we still have with us the following Fellows:—

Brown, Isaac, F.R.A.S.	Perigal, H., F.R.A.S.
*Glaisher, J., F.R.S.	Prince, C. L., F.R.A.S.
Hippisley, J., F.R.S.	*Slatter, Rev. J., F.R.A.S.
*Johnson, W., F.R.A.S.	Tudor, E. O., F.S.A.
*Lowe, E. J., F.R.S.	

The Council have been materially assisted by several Committees, which were constituted as follows:—

General Purposes Committee. – President, Secretaries, Foreign Secretary, Treasurer, Messrs. Ellis, Inwards, and Latham.

Editing Committee.—Messrs. Inwards, Maclear, and Scott.

Wind Force Committee.—President, Secretaries, Messrs. Binnie, Chatterton, Curtis, Dines, C. Harding, Laughton, Munro, and Scott.

Standing Referee on Papers.—Mr. Ellis.

Instead of the Annual Exhibition of Instruments, which has now been a feature of the Society's Session for the past 18 years, at the request of the Council, Mr. Shelford Bidwell, F.R.S., delivered a lecture on "Some Meteo-

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rological Problems," illustrated by numerous electrical experiments. The lecture was extremely well attended.

Stations.—Observations have been accepted from the following new stations:—Chester; Cranleigh, Surrey; Folkestone, Kent; Halstead, Essex; Lancaster; Newport, Pembrokeshire; and Newquay, Cornwall. The observations have been discontinued at Babbacombe and Exeter.

Copies of detailed monthly returns and annual summaries of results have been supplied as usual to the Meteorological Office.

Inspection of Stations.—All the stations north of latitude 52° N. and east of longitude 2° W., together with such other stations west of longitude 2° W. as were not inspected last year, have been visited, and found to be on the whole in a satisfactory condition. Mr. Marriott, in his Report (which will be found in Appendix III., p. 100), states that he has called the special attention of the observers to the working of the wet bulb thermometer, particularly during frost.

Dinner to Mr. Perigal.—A Congratulatory Dinner at Limmer's Hotel, on Saturday, April 15th, was, on the initiation of the Society, given to Mr. Perigal, in celebration of his 92nd birthday and of his 40 years' service to the Society as Treasurer.

Research Fund.—Dr. C. Theodore Williams, previous to vacating the office of President, has expressed a desire for the formation of a fund for carrying out experiments and observations in Meteorology, and has generously presented the sum of £100 to form the nucleus of a Research Fund. The Council have gratefully accepted this donation, and trust that this Fund may be augmented by interest and otherwise as time goes on, and that it may be the means of forwarding the objects of the Society in future.

Donations.—A valuable present of a lime-light lantern and all the necessary apparatus for use in illustrating the papers read at the Society's Meetings has been received from the President. Considerable additions have been made to the Library during the year, a list of which will be found in Appendix V., p. 118. Several Photographs have been received from different donors.

Quarterly Journal.—This publication has contained several interesting papers, amongst which are "The High Altitudes of Colorado and their Climates," by the President; "Remarks on the Measurement of the Maximum Wind Pressure, and description of a new instrument for indicating and recording the same," by Mr. Dines; "The relation between the duration of Sunshine, the amount of Cloud, and the height of the Barometer," and "The Mean Maximum and Mean Minimum Temperature of the Air on each day of the year at the Royal Observatory, Greenwich, on the average of the fifty years, 1841-90," by Mr. Ellis; "Suggestions, from a practical point of view, for a New Classification of Cloud Forms," by Mr. Gaster; and "Fifteen Years' Fogs in the British Islands, 1876-90," by Mr. Scott.

Meteorological Record.—This publication has been brought up to June 1893.

Phenological Report.—This interesting and instructive Report was read

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by Mr. Mawley at the February meeting, and it is satisfactory to find that the number of observers has been well maintained.

The New Offices.—These continue to give satisfaction, and have proved very convenient.

Hour of Meeting.—In view of the repeated requests of numerous Fellows, the Council resolved to alter the hour of Meeting for the current Session from 7 p.m. to 8 p.m., a change which they trust will be conducive to the comfort of the Fellows, and lead to a larger attendance at the Meetings.

Fellows.—The changes in the number of Fellows during the year are exhibited in the following table, which shows an increase of three:—

Fellows.	Annual.	Life.	Honorary.	Total.
1892, December 31st...	399	137	19	555
Since elected	+48	+1	...	+44
Deceased.....	− 8	−3	−2	−13
Retired	−19	...	...	−19
Lapsed	− 8	...	...	− 8
Defaulters	− 6	...	...	− 6
1893, December 31st...	406	135	17	558

Deaths.—The Council have to announce with much regret the deaths of eleven Fellows, and of two Honorary Members. The names are:—

John Charles Bell, F.R.G.S.	elected	Feb. 15, 1888.
Henry Francis Blanford, F.R.S., F.G.S.	,,	Nov. 20, 1878.
Edith Brooke	,,	Dec. 19, 1883.
Sir Andrew Clark, Bart., M.D., F.R.S., Pres.R.C.P.	,,	Apr. 20, 1892.
Prof. Daniel Colladon (Honorary Member)	,,	May 16, 1888.
Prof. Henri Marié Davy (Honorary Member)	,,	Apr. 17, 1878.
Earl of Derby, K.G., M.A., LL.D., F.R.S.	,,	Mar. 19, 1879.
Lord Ebury, F.R.G.S.	,,	May 7, 1850.
William John Harris, M.R.C.S.	,,	Nov. 20, 1867.
Thomas Hawksley, F.R.S., M.Inst.C.E., F.G.S.	,,	Jan. 22, 1856.
Captain John Shortt, R.N.	,,	Dec. 18, 1889.
Lieut.-Col. William Stuart	,,	Nov. 20, 1878.
George Matthews Whipple, B.Sc., F.R.A.S.	,,	Apr. 15, 1874.

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APPEN-

STATEMENT OF RECEIPTS AND EXPENDITURE

Receipts.

	£	s.	d.	£	s.	d.
Balance from 1892				142	11	4
Subscriptions for 1893	685	2	0			
Do. former years	62	15	0			
Do. paid in advance	36	2	0			
Life Composition	21	0	0			
Entrance Fees	35	0	0			
				839	19	0
Meteorological Office—Copies of Returns	143	10	3			
Do. Grant towards Inspection Expenses	25	0	0			
				168	10	3
Dividends on Stock (including £40 5s. 8d. from the New Premises Fund)				114	13	8
Sale of Publications				32	2	1
				£1297	16	7

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PENDIX I.

FOR THE YEAR ENDING DECEMBER 31ST, 1893.

EXPENDITURE.

	£ s. d.	£ s. d.
Balance due to the Assistant-Secretary		2 5 6
Journal, &c.:—		
Printing Nos. 85 to 88	105 10 6	
Illustrations	45 0 8	
Authors' Copies	16 16 6	
Meteorological Record, Nos. 47 to 50	50 9 6	
Registrar-General's Reports	8 8 0	
		226 5 2
Printing, &c.:—		
General Printing	24 1 6	
Stationery	5 4 1	
Forms	11 3 6	
Books and Bookbinding	28 18 1	
		69 7 2
Office Expenses:—		
Salaries	417 5 5	
Rent and Housekeeper	141 14 0	
Furniture, Repairs, Coals, &c.	15 9 10	
Postage	47 12 0	
Petty Expenses	16 0 11	
Refreshments at Meetings	14 1 1	
Lecture Expenses	12 1 0	
Subscriptions overpaid returned	4 0 0	
		668 5 3
Observations:—		
Inspection of Stations	54 0 7	
Observers at Old Street and Seathwaite	7 2 0	
Instruments	4 15 7	
		65 18 2
Stock:—		
Purchase of £100 2½ per cent. Annuities		97 5 0
		1129 6 3
Balance:—		
At Bank of England	165 13 3	
In hands of the Assistant-Secretary	2 17 1	
		168 10 4
		£1297 16 7

Examined and compared with the Vouchers, and found correct,

J. S. HARDING, JUNR.,
ALBT. E. WATSON, } *Auditors.*

January 9th, 1894.

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APPEN-

ASSETS AND LIABILITIES

Liabilities.

	£	s.	d.
To Subscriptions paid in advance	36	2	0
„ Excess[1] of Assets over Liabilities	2751	7	11
	£2787	9	11

[1] This excess is exclusive of the value of the Library and Stock of Publications.

NEW PREMISES FUND,

	£	s.	d.
Amount paid to the Society's Funds towards the increased rent of the New Premises	40	5	8
Amount invested in purchase of £13 8s. 10d. South Australian 3½ per cent. Inscribed Stock	12	10	0
	£52	15	8

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DIX I.—Continued.

ON JANUARY 1ST, 1894.

ASSETS.	£ s. d.	£ s. d.
By Investment in M. S. and L. R. 4½ per cent. Debenture Stock, £800 at 142	1136 0 0	
„ Investment in N. S. W. 4 per cent. Inscribed Stock, £654 18s. at 104¼	682 14 8	
„ Investment in L. & N. W. R. Ordinary Stock, £200 at 164	328 0 0	
„ Investment in 2½ per cent. Annuities, £100 at 97¼	97 5 0	
		2243 19 8
„ Subscriptions unpaid, estimated at	50 0 0	
„ Entrance Fees unpaid	10 0 0	
„ Interest due on Stock	30 3 10	
		90 3 10
„ Furniture, Fittings, &c.	184 19 10	
„ Instruments	99 16 3	
		284 16 1
„ Cash at Bank of England	165 13 3	
„ Cash in hands of Assistant-Secretary	2 17 1	
		168 10 4
		£2787 9 11

J. S. HARDING, JUNR., ALBT. E. WATSON, } *Auditors.*
WILLIAM MARRIOTT, *Assistant Secretary.*

January 9th, 1894.

DECEMBER 31ST, 1893.

	£ s. d.
Contributions of Fellows	12 10 0
Interest received on investment	40 5 8
	£52 15 8

NOTE.—The Society holds on account of this Fund £1199 0s. 2d. South Australian 3½ per cent. Inscribed Stock.

J. S. HARDING, JUNR., ALBT. E. WATSON, } *Auditors.*
WILLIAM MARRIOTT, *Assistant Secretary.*

January 9th, 1894.

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APPENDIX II.

Subscriptions promised towards the New Premises Fund.

FOURTH LIST.

	£	s.	d.
Amount already promised	1,176	7	6
Mr. O. B. Cuvilje	2	0	0
	£1,178	7	6

APPENDIX III.

Inspection of Stations, 1893.

During this year I have visited all the stations north of 52° N. lat., and east of 2° W. long., together with such other stations west of 2° W. long. as were not inspected last year.

The stations as a whole were in a satisfactory condition, and the observers appear to take an intelligent interest in the work. Fewer changes than usual have occurred in the zeros of the thermometers.

This year I took with me some brass back-plates having a hole and slot for suspending the thermometers. These I substituted, where necessary, for the back-plates having only a ring, in order to obviate the vibration of the maximum and minimum thermometers in windy weather. I also renewed the metal fastenings for holding the thermometer tubes when they were almost or quite worn away.

The observers have been urged to give as much attention as possible to the working of the wet-bulb thermometer, especially during frost.

I have to report that the charge of the observations at Blackpool has been transferred from the Borough Surveyor to the Medical Officer of Health. The instruments have also been removed to property belonging to the Corporation, and there is every reason to expect that the observations will be thoroughly satisfactory.

WILLIAM MARRIOTT.

October 18th, 1893.

NOTES ON THE STATIONS.

APPLEBY, *August 26th.*—The instruments were all clean and in good order. I rearranged the position of the water receptacle, and urged the observer for the future to read the thermometers to tenths instead of to whole degrees.

BELPER, *September 2nd.*—The instruments were in the same position as formerly, the thermometer screen being greatly sheltered by trees. I put on fresh back-plates to the minimum thermometer. The amount of cloud seems to be somewhat under-estimated.

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BLACKPOOL, *August 30th.*—The charge of the instruments and the observations had recently been transferred from the Borough Surveyor to the Medical Officer of Health. Mr. F. Pool, one of the Sanitary Inspectors, is the observer, and he appears to be an efficient man. The rain gauge was sheltered by a row of willow bushes. In order to get the instruments together on Corporation land, I went to the Sanatorium and selected a fresh site, which will be more open and satisfactory than the present one.

BOLTON, *August 31st.*—The thermometers were all correct, except the minimum, which had gone down 0°·8. The funnel of the rain gauge required repairing. Observations with a 6 inch earth thermometer were commenced on January 1st.

BURTON ON-TRENT, *August 1st.*—All the instruments were in good order, except the grass minimum, which had 1° of spirit at the top of the tube.

BUXTON, *September 1st.*—The observations are now made by the Medical Officer of the Devonshire Hospital, and are more efficiently taken than formerly. The thermometers were all correct. The results from the sunshine recorder would no doubt be better if the instrument were placed in a more satisfactory position.

CHEADLE, *July 31st.*—The instruments were in good order.

CHESTER, *July 29th.*—The instruments are mounted in a small garden in the Park Gate Road, the exposure is very fair but somewhat confined. The thermometers required rearranging in the screen, and also holes to be cut behind the bulbs of the maximum and minimum. None of the thermometers except the grass minimum had been verified at Kew. [The instruments have subsequently been sent to Kew for verification.]

CORTON, *July 19th.*—The sunshine recorder is by Messrs. Negretti and Zambra, and is placed in a well exposed position near the cliff.

DRIFFIELD, *July 13th.*—Everything was in good order, and the thermometers were all correct. Mr. Lovel had added a barograph and evaporation tank to his equipment since the last inspection. [Mr. Lovel died on February 16th, 1894, but the observations will be continued by his father, Mr. W. E. Lovel.]

GELDESTON, *July 20th.*—The sunshine recorder is mounted on the ridge of a stable, and is very well exposed. A tree on the east is the only thing likely to at all intercept the sun's rays.

HALSTEAD, *September 27th.*—The instruments are placed on a grass plot in a kitchen garden, and are well exposed. I recommended an alteration in the mounting of the dry and wet thermometers. The dry and wet had both gone up 0°·2.

HARROGATE, *July 11th.*—Since the last inspection the instruments have been removed from the West End Park to the Bog Valley Gardens. They are in a good situation, and are well exposed. The observations are now under the charge of Mr. J. Farrah. The sunshine recorder (Jordan pattern) is placed on the top of the tower of the Hydropathic Establishment, and is very well exposed.

HILLINGTON, *July 18th.*—The thermometers were all correct. The sunshine recorder was not quite level. This I endeavoured to adjust.

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HODSOCK, *September 4th.*—This station was in good order. The ball of the sunshine recorder was not quite in the centre of the frame. This I adjusted, and Mr. Mellish has had the slate slab fixed in cement.

KENILWORTH, *August 2nd.*—Both Mr. Hawley and the coachman, who usually takes the observations, were away at the time of my visit. The thermometer screen needed painting, and the legs renewing. The thermometers required rearranging in the screen. The tubes of the maximum and minimum had slipped down. These I readjusted.

LANCASTER, *August 30th.*—The instruments are placed in the Williamson Park, which was formerly moor land, and had been used as a quarry. The ground is consequently irregular, but the instruments are placed on the highest points. The thermometer screen required to be painted white and also to be raised, as the bulbs of the thermometers were only 3ft. 4 ins. above the ground. The tube of the maximum had slipped down 1°. The sunshine recorder is mounted on the roof of the Greg Observatory. The observations are made by the Curator of the observatory.

LLANDUDNO, *July 28th.*—All the thermometers were in good order except the minimum, which had 0°·5 of spirit at the top of the tube. I recommended that a cover be placed over the water receptacle. The sunshine recorder on the pier was somewhat out of focus. This I readjusted. The hills on the west cut off the sun in the evening, the highest point making an angle of 11°.

LINCOLN, *September 6th.*—There was no change in the thermometers. I recommended that a cover be placed over the water receptacle. The electrical thermometer was in good order. The screen on the tower required painting.

LOWESTOFT, *July 19th.*—There was no change in the thermometers. The tube of the maximum had slipped down. This I readjusted. The mercury in the maximum thermometer had a tendency to run up 2° or 3°. I called attention to this, and requested that the thermometer might be hung with the bulb a little lower.

MACCLESFIELD, *September 1st.*—The thermometers were all correct except the wet bulb, which had gone up 0°·1. One of the hinges of the door of the screen was broken and needed repairing.

NORTHWICH, *July 26th.*—The thermometers required to be rearranged and the screen painted. The lower part of the tubes of the dry and wet-bulb thermometers not being readable, owing to the piece of wood across them, I had this cut so that the tubes are now quite clear. The minimum had 0°·6 of spirit up the tube.

RAVENSTHORPE, *August 2nd.*—The dry and wet-bulb thermometers had gone up 0°·2. I recommended that the minimum be set horizontal and fixed tighter, to prevent vibration, and also that a cover be put over the water receptacle. A board with holes has been placed at the back of the stand, and is painted white.

ROTHBURY, *August 19th.*—The wet-bulb thermometer was not working properly, as the muslin was out of order. I altered the position of the maximum and minimum, and also put on fresh back-plates with slots. As there

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was a piece of wood across the tubes of the dry and wet-bulb thermometers at about 25°, I recommended that this should be cut away, so that the column of mercury might be seen entire.

ROUNTON, *August 18th.*—The instruments were in good order, except the black-bulb maximum *in vacuo*, which had lost its index. As the wooden stick carrying the earth thermometer was rotting away, I recommended that it be bound round with wire. The observer was requested to give special attention to the wet-bulb thermometer during frost.

SCALEBY, *August 26th.*—The muslin on the wet-bulb was dry, and had not been kept in good order. The tubes of the dry and wet thermometers being loose, I put on fresh brass loops and screws. The screen required painting.

SCARBOROUGH, *July 12th.*—The observations are now taken by Dr. Monk, the Medical Officer of Health. The instruments are placed in a small garden with a very confined exposure. It is the only place available without going to such a distance that the instruments would not be under the supervision of the observer. The garden is about 200 feet east of Mr. Robinson's (the former observer), and is on the same level. The rain gauge is somewhat sheltered on the north-east by a tree which makes a considerable angle. I recommended that some branches of the tree be lopped. The screen required painting, and the thermometers rearranging.

SEATHWAITE, *August 28th.*—There was no change in the thermometers. I altered the position of the maximum and put on new back-plates. The amount of cloud appeared to be over estimated.

SOMERLEYTON, *July 19th.*—The instruments were all in good order, except the minimum, which had gone down 0°·5. As the Rev. C. J. Steward had two earth thermometers at 4 feet, one in a drain pipe and the other in an iron pipe, I suggested that the former should be put at 1 foot.

SOUTHWELL, *September 5th.*—All the thermometers were correct except the earth thermometer which had gone up 0°·1. The glass ball of the sunshine recorder was not quite in the centre of the frame. This I readjusted. The traces show that the sunshine has not been recorded in the morning before 5 a.m., while in the evening it has been recorded up to 8 p.m., and on June 9th, 1892, up to 8.5 p.m.

SUTTON COLDFIELD, *August 1st.*—The instruments have been moved to a site about 100 feet south of their former position. They are somewhat close to two ponds of water. The observations since January 1st have been taken only once a day, viz. at 9 a.m., instead of twice a day, viz. at 9 a.m. and 9 p.m., as formerly. I recommended that a cover should be put over the water receptacle. The screen required painting.

THORESBY (North), *July 14th.*—The instruments are placed in a paddock between the Rectory and the Church, and are well exposed. The ground is flat from the sea to the Wolds. North Thoresby is about 5 miles from the sea, and 2 miles from the Wolds. There was no change in the thermometers, which are those which the Rev. H. Garrett had formerly at Southampton. The muslin on the wet bulb was dry, the cotton not conducting properly. I recommended that a cover be placed over the water receptacle.

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THURLOW, *September 27th.*—The muslin on the wet-bulb was dry, the cotton not conducting properly. I altered the position of the screws of the maximum thermometer as the mercury was liable to run up the tube. I recommended that the thermometers should be read to tenths instead of to whole degrees, and also that more attention should be given to the wet bulb.

USHAW, *August 18th.*—The thermometer screen required painting and strengthening. A new rain gauge was necessary as the existing one was completely worn out. I recommended that a cover be placed over the water receptacle.

WAKEFIELD, *July 10th.*—There was no change in the thermometers. The screen required painting and the thermometers re-arranging. As the water receptacle was liable to be burst in frost, I recommended that a fresh one with a cover be obtained. The observations will in future be entered direct in the original observation book instead of on loose pieces of paper.

WINDERMERE, *August 29th.*—The instruments are placed in a small yard or garden, the exposure is consequently very confined. The rain gauge is placed on a wall 6 feet above the ground. Mr. Mackereth has had, however, three gauges placed in open situations, and always found that they collected the same amount as that on the wall.

WORTHING, *October 11th.*—I called on Mr. G. B. Collet at Shelley House and found him willing to carry on the observations so ably taken by the late Mr. W. J. Harris during the past 26 years. I selected a site for the instruments, which would be put in position before the end of the month.

WRYDE, *July 17th.*—There was no alteration in the thermometers, but I found that the maximum read too high by the mercury having a tendency to run up the tube. This I remedied by lowering the bulb and also by tightening the screws to prevent vibration. The tube of the maximum thermometer had slipped down about a degree. This I readjusted.

APPENDIX IV.

OBITUARY NOTICES.

HENRY FRANCIS BLANFORD, who died after a protracted illness on January 23rd, 1893, was born in 1834, in Bouverie Street, in the house now the offices of the *Daily News*. He was one of the students of the Royal School of Mines at its opening in 1851, and like other meteorologists, such as the late Prof. Buys Ballot, Prof. Mohn, and Mr. Scott, his earliest work was Geological. He studied at Freiberg for a year, and joined the Geological Survey of India in 1855. He had to leave that service in 1862, as his health would not stand the exposure to climate involved in geological exploration, but in those seven years he did work, the permanent value of which has been thoroughly recognised.

In 1862 he joined the Educational Department, and was soon appointed Professor of Physics in the Presidency College of Calcutta. He began to

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devote himself to meteorological inquiries, and when the Calcutta Cyclone of October 1864 forced on the notice of the Government the desirability of organising storm warnings, Mr. Blanford was appointed Honorary Secretary to the Meteorological Committee, charged with the arrangements for a tentative scheme of this nature. Soon after he was formally appointed Meteorological Reporter to the Government of Bengal, and in 1875 he was finally constituted Director of the Central Office, or Meteorological Reporter to the Government of India. In March 1887 he took furlough for 21 months, and on its expiration he retired.

His *Indian Meteorologist's Vade Mecum*, published in 1877, is the best book of Instructions for all tropical countries, and in his *Weather and Climates of India*, published in 1889, he gives the results of his life's work in the investigation of the Climate of the Indian Peninsula.

The *Indian Meteorological Memoirs* contain numerous papers from his pen, and his name also appears in the Royal Society's *Proceedings*, and in the *Philosophical Transactions*, as well as in the *Proceedings of the Asiatic Society of Bengal*. He became F.R.S. in 1880, and was an honorary member of several foreign Meteorological Societies.

He was elected a Fellow of this Society on November 20th, 1878, and served on the Council from 1888 to 1891. R. H. S.

Sir Andrew Clark, Bart., M.D., LL.D., F.R.S., was born on October 28th, 1826, at Aberdeen, and educated at the Universities of Aberdeen and Edinburgh, where he highly distinguished himself. He graduated M.D. at Aberdeen in 1854, and became a Surgeon in the Royal Navy and later on Pathologist to the Royal Naval Hospital at Haslar.

However, it was not until he came to the Metropolis, and was appointed a member of the Medical Staff of the London Hospital, that he made his mark. By long and patient study of morbid anatomy, he became first a great pathological teacher, and, connecting this with bedside experience, a distinguished clinical lecturer, attracting crowds of admiring students and practitioners. He subsequently became involved in a large consulting practice, which he retained up to his death.

Sir Andrew Clark was President of several of the Medical Societies, including the Medical, the Clinical, and Hunterian, and at the time of his death presided over the Royal Medico-Chirurgical Society, in whose debates he took a warm interest. But of late years, his principal public work was in connection with the Royal College of Physicians, in which he held the various offices of Examiner, Croonian and Lumleian Lecturer, and eventually President, which office he held up to the last with the greatest dignity and ability, and with the utmost devotion to the interests of the College and of the Medical Profession. He was attacked with apoplexy while seeing his patients as usual, and died, as he would have desired, at his post, on November 6th, 1893, aged 67.

His chief characteristics were, first, his untiring energy and extraordinary power of work; secondly, his great sympathy with suffering, and ready

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resource in its alleviation; thirdly, his eloquence, both of speech and of pen, which enabled him to elucidate most complex questions, to champion with success many a good cause, and last, but not least, to give his medical directions in such clear language that they could not be misunderstood.

Sir Andrew Clark's funeral service, November 11th, 1893, was held in Westminster Abbey, and largely attended by his friends and patients, among them Mr. Gladstone, who was a pall bearer. He was buried at Essendon, in Hertfordshire.

He was elected a Fellow of this Society on April 20th, 1892, and always expressed much interest in Climatology. C. T. W.

DANIEL COLLADON was born at Geneva, Switzerland, in the year 1802, and educated in that town. In early life he took much interest in Physical Science, and evinced considerable aptitude in experimental inquiry in Natural Philosophy. At 28 years of age he had to conform to the law of the country and undergo military training, which he appears to have rather enjoyed. We next find him engaged for two years attending lectures in Philosophical Science at the Geneva Academy; during that time his inquiring turn of mind set him to work on various topics, and in 1825 he published a paper together with Dr. Prevost, of Geneva, on a phenomenon described by Arago concerning the influence of metallic plates on magnets. Arago was then the centre of the physical world on the Continent, and it is not surprising that Colladon should have felt a great desire to make his acquaintance. With this object he proceeded to Paris in company with Sturm, who subsequently distinguished himself greatly as a physicist and mathematician.

On his arrival in Paris, Colladon found that the great topic of interest was the construction of a passage under the Thames, with which the engineer, Mr. Brunel, was actively engaged; the tunnel had then reached half way under the river, when suddenly a violent irruption of water took place, and the works had to be interrupted. Colladon then suggested to Mons. de Lessert, who had subscribed largely to the funds required for the undertaking, that it might have added to the safety of the boring to undertake the work under compressed air, one or two atmospheres being probably sufficient, supposing the tunnel to be closed by an iron shutter and the air compressed within it by means of powerful pumps. Colladon put his suggestion in writing, and the letter was forwarded to Brunel, but no answer was ever returned to it. It seems, however, that on a later occasion Brunel recollected Colladon's suggestion.

Colladon while in Paris became acquainted with Arago, Ampère, and Humboldt, and was naturally led to investigate the subject of electricity. He succeeded in causing a deviation of the magnet through the agency of an electric friction machine, and up to that time such an effect was only known to be produced by a voltaic pile. Colladon's attention was next turned to atmospheric electricity. A metallic point was fixed to the end of a long rod, and this he erected on the Observatory of the "Collège de France,"

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and placed alongside of the lightning conductor, which it exceeded in height by more than one metre. The point was enclosed in a glass tube and two conductors, isolated by means of silk let down from the end of the point into a room where they were fixed to a galvanometer Colladon himself had invented. A storm occurring at the time, no sooner was the apparatus mounted than the needle of the galvanometer was deviated in such a way as to show the electricity to be negative. Two days later another more violent storm occurred, and during 20 minutes the direction of the currents changed two or three times. Wishing to break the conductor at the moment of the maximum deviation of the galvanometer, Colladon received a succession of powerful spark discharges.

Shortly afterwards Colladon entertained the idea of determining the rate of transmission of sound through water, and returned to Geneva to carry out his experiments in the lake. This he did at night by placing a person at a distance of 14,237 metres, while he himself was in a boat; this person fired a rocket, and at the same moment struck a bell with a hammer, the bell being immersed in the lake; the sound was perceived through a long tube bent at its immersed end, and widened somewhat like a trumpet; the wide immersed extremity of tube was closed by a diaphragm. He observed the time required for the transmission of the sound with a watch. A great number of experiments were made, and finally Colladon found for the transmission of sound through water a speed of 1,435 metres per second.

Atmospheric electricity was evidently a favourite study for Colladon, and in 1826 and 1827 he made some very interesting experiments near Geneva, selecting two stations at a difference of altitude of 780 metres. These observations confirmed the accepted opinion that in fine weather the atmosphere in plains, except where under the influence of trees, smoke or overhanging buildings, is electrified positively at a few metres above the earth.

About this time Colladon, who had given much attention to steam engines, became actively engaged as a Consulting Engineer; we now pass over a portion of his career, mostly devoted to engineering, and coming to his researches more strictly meteorological, we find him busy with observations on hail.

He was led to his theory of the formation of hail by a phenomenon he remarked in waterfalls, where he had observed an upward current of air to be produced by the falling water, this current causing an upward motion of the water particles on the outer layer of the fall. According to Colladon's theory, the production of hail is owing to the formation of a vertical descending air current produced by a sudden and heavy shower; this current leaves behind a vacuum, or a considerable fall of pressure, mostly located in the cloud from which originated both the shower and the hail. Thus, in that cloud there is a permanent indraught of air as long as the storm lasts. This indraft brings to the cloud cold and dry air from above, as well as air from below, the upper air being strongly electrified and possibly mixed with acicular ice crystals or drops of water in the process of freezing. The draught thus produced would divide the cloud into a number of portions differently

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electrified, and consequently the hailstones would be attracted and repelled by these separated cloud masses, increasing in size all the while.

This view on the origin of hail led Colladon to inquire into the formation of tornadoes, and he contended that tornadoes were not all descending, as was thought to be the case according to Fay's law, but that they are sometimes ascending. He founded this view on numerous observations of whirlwinds, in which dust and various terrestrial objects were lifted into the air by a tornado and deposited at some distance from the spot over which the tornado had passed. One of the most interesting of those observations relates to a tornado which passed over the town of Geneva, and swept within its sphere of action a quantity of clothes hung up to dry; the circular movements of these clothes mixed with masses of dust indicated clearly the gyration of a column of air 8 metres in diameter; he estimated the height of this tornado at 600 metres.

The effects of lightning on trees and plants were subjects of great interest to Colladon, and he examined these effects closely on poplars, oaks, elms, cherry trees, pear trees, firs, cedars, horse chestnuts, walnut trees, plane trees, and vines. With reference to poplar trees he was surprised to find that in some instances no signs of being struck by lightning could be seen on the upper four-fifths of the tree. He noticed in one case two longitudinal wounds in the bark, in the middle of which there appeared a longitudinal slit 1 or 2 millimetres in thickness, where the blade of a knife could be inserted to a depth of 3 or 4 centimetres; along those slits two well defined bands or lips were visible 4 or 5 millimetres in breadth; these bands were coloured light brown, like wood dried in an oven, but the most remarkable feature was the occurrence of seven perfectly round spots 8 to 10 millimetres in diameter, disposed along the slit at a mean distance of 1·80 metre above the soil.

He described as follows the lightning spots on a fir tree:—"On the inferior portion of the trunk, at a height of 2·60 metres, ten circular spots could be seen placed along a fissure in the wood. These circles or spots vary in diameter from 3 to 5 centimetres; they are situated at the surface of the young wood, their colour is dark brown, slightly darker near their circumference; they have a depression at the centre from 1 to 2½ millimetres in depth. Those ten circles are traversed by the slit which intersects them either through their centre or at the sides." Summing up the subject of those spots, he remarks that he has observed them on eight different trees.

He finally observed the effects of lightning on vineyards. In vineyards struck by lightning he found that the damaged extent distinguished itself from the rest of the plantation by the presence of numberless spots on many of the leaves of a brick red colour. These spots were irregular, and covered a third, or perhaps half, the surface of the leaves. Other irregular spots were also observed, exceeding the former in number and coloured dark blackish green. He leaves it an open question whether the dark green spots become or not the seat of the brick-red coloration; according to the manager of a vineyard under Colladon's observation, the dark green spots

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were the primary effects of the lightning, and after some days they assumed the brick-red colour. Colladon had opportunities for the examination of 17 different vineyards struck by lightning; in nearly every case a circular or elliptic region from 8 to 18 metres in diameter had suffered.

Colladon was greatly distinguished as an Engineer, and perhaps his most remarkable invention was his perforating machine, worked by compressed air, which was successfully used in the Mont Cenis Tunnel. He was also Professor of Mechanics at the École Centrale of Paris and Academy of Geneva. The author of this biographical notice had the pleasure of Colladon's personal acquaintance, and will ever recollect his kindly and genial welcome.

Daniel Colladon died on June 30th, 1893, and was therefore in his 91st year of his age, his active mind being at work to the very last. He wrote an autobiographical volume, from which the present notice of his life has been extracted.

He was elected an Honorary Member of this Society on May 18th, 1888.

W. M.

Professor Henri Marié Davy, who died at Clamecy, Nièvre, in July at the age of 72 years, had been elected a Foreign Member of this Society on April 17th, 1878. He took his Doctor's degrees in Medicine, Physical Sciences and Mathematics in Paris, in 1840, and he successively held Professorships of Physics at various provincial Colleges in France. Rouen was one of these. Soon after the organisation of the Meteorological Service at the Observatoire de Paris, he was appointed by Leverrier to superintend that department of the observatory work. In 1866, he brought out his Meteorological work *Les Mouvements de l'Atmosphère et les Variations du Temps*, a book which reached a second edition in 1877.

Differences of opinion between Professor Marié Davy and his chief severed the relations between them, and he left the Observatory some time before 1870. After the war, in 1873, he came back to Paris as Director of the Montsouris Observatory, an establishment in relation with the Paris Municipality, where, as is well known, not only Meteorology, but the microscopic examination of air and rain and Terrestrial Magnetism are prosecuted. He held that post until 1887.

Henry Edward Stanley, Earl of Derby, was born in July 1826. He was educated at Rugby, under Arnold, and at Cambridge, where, as a student of Trinity College, he gave promise of his future success in life. He obtained a first-class in the classical tripos, and also took honours in mathematics.

From 1848 to 1869, when he succeeded his still more celebrated father, the fourteenth Earl of Derby, he represented the borough of King's Lynn. He entered upon a long and eventful Ministerial career at the exceptionally early age of 26, his first office under the Crown being the not unimportant one of Under Secretary of the Colonies. Subsequently Lord Palmerston, anxious

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to secure his support, placed the Colonial Secretaryship at his disposal. The offer, though declined, was a great compliment to the ability of a man not yet 40.

As a member of his father's second Cabinet, Lord Stanley, as he was then, had charge of the Bill transferring the government of India from the Company to the Queen, and the manner in which he piloted that historic measure through the House of Commons greatly increased his reputation. At a later period he twice filled the post of Secretary of State for Foreign Affairs, and more recently he was Secretary of State for the Colonies, a position he had occupied for a short time in earlier years.

Lord Derby was much sought after for Royal Commissions, where his practical knowledge, sound sense and clear judgment were of considerable advantage to the State. He served as a Member of the Royal Commission on Army Purchase (1856-7); of the Cambridge University Commission (1856-60); and of the Commission of the Organisation of the Indian Army (1858-9). He was Chairman of the Commission on the Sanitary State of the Indian Army (1859-61); of the Commission on Patents (1863-4); of the Commission on City Guilds (1881-2); and of the Commission on Market Rights and Tolls (1888-90).

Lord Derby was distinguished among politicians for the genuine interest he displayed in social questions, and this interest with him was not a thing of yesterday.

Not a few scientific or academic distinctions fell to his lot. Among the former may be mentioned his Fellowship of the Royal Society. His *alma mater* made him an LL.D., and Oxford gave him her degree of D.C.L. He was installed Lord Rector of Glasgow University in 1869, and Lord Rector of Edinburgh University in 1875. He succeeded the late Earl Granville as Chancellor of the University of London.

Though he never attempted anything so elaborate as his gifted predecessor's translation of Homer's *Iliad*, he was not destitute of literary skill. Among the pamphlets he wrote was one on the *Overland Route to the Pacific*, and another on *Church Rates*. He also published, as a young man, a readable *brochure*, entitled *Six Weeks in South America*.

Of late he had withdrawn very largely from active politics. In many other spheres he will be much missed.

Lord Derby died on April 20th, 1893.

He was elected a Fellow of this Society on March 19th, 1879.

Lord Ebury was born on April 24th, 1801. He was the third son of the second Earl and first Marquess of Westminster, his eldest brother subsequently succeeding to the family dignities and his second brother becoming Earl of Wilton. Lord Ebury was consequently uncle to the present Duke of Westminster.

Educated at Westminster and at Christ Church, he entered the House of Commons as Whig member for Shaftesbury in 1822, a seat which he held for four years. From 1826 to 1847 he represented the city of Chester, and

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from 1847 to 1857 the county of Middlesex. On Lord Grey becoming Prime Minister in the autumn of 1830, Lord Ebury, then Lord Robert Grosvenor, became Comptroller of the Household, and in Lord John Russell's Ministry of 1846 he resumed office as Treasurer of the Household and Groom of the Stole to the Prince Consort. Eleven years later he received, on the recommendation of Lord Palmerston, the honour of a peerage, taking his seat in the Upper House as Lord Ebury. At the time of his death, on November 18th, 1893, he was the oldest member of the House of Lords. He was also far the oldest Privy Councillor, having been a member of that body some years when the Queen came to the throne.

As a politician Lord Ebury filled no considerable space in the events of recent years. He was much more concerned with matters of philanthropic and religious interest, in which he was frequently associated with the late Lord Shaftesbury.

Lord Ebury always took a great interest in Meteorology, and in 1838 served on the Council of the original Meteorological Society of London. In the following year he was elected President, and continued to hold that office until the dissolution of the Society on August 14th, 1850. Lord Ebury joined the newly formed British (now the Royal) Meteorological Society on May 7th, 1850, and was then elected Vice President, a position which he occupied till May 27th, 1856.

William John Harris was educated at the Merchant Taylors' School, and afterwards proceeded to St. Bartholomew's Hospital for the study of medicine. He joined his father in practice at Worthing, and ultimately became one of the leading medical men of that town.

He became M.R.C.S. in 1859, and was a member of several Medical Societies. He was President of the South-Eastern Branch of the British Medical Association, 1886-7.

Mr. Harris took a prominent part in all the social, philanthropic and educational movements in Worthing. He was a member and for several years Chairman of the Local Board.

He suffered much from paralysis during the last few years of his life, and retired from practice about a year before his death. He died from typhoid fever on August 28th, 1893, aged 55 years.

Mr. Harris was greatly devoted to Meteorology, and took observations at Worthing from 1867 to the time of his death.

He was elected a Fellow of this Society on November 20th, 1867, and served on the Council for 1875.

Thomas Hawksley was born at Nottingham in 1807. He was educated as an architect and surveyor, but, having an inclination for mechanical pursuits, he studied diligently the sciences necessary to enable him to practise as a civil engineer, and with such success that in 1830 he undertook the construction of new waterworks for his native town. The knowledge and skill he exhibited in these works led to more practice in other districts, and

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in 1852 he removed his offices to London, where before long he took the highest rank in that branch of engineering having to do with water and gas supply, and with drainage and hydraulic works generally.

Mr. Hawksley was accustomed to say that he had constructed above 150 waterworks, many of the largest character; and that there were no important towns in Great Britain, and indeed very few great cities in the civilised world, in regard to which he had not been professionally consulted in some way or other. He is especially celebrated for having been the first to suggest and to carry into practice the system of "constant service" in water supply, which combined the most free and ample provision of water with the almost perfect repression of waste, and with greatly improved sanitary conditions. The introduction of the system involved many difficulties and much opposition; but he always spoke of his success in it with great satisfaction and pride.

It must not be supposed that municipal engineering in the days of Mr. Hawksley's early practice meant simply building and mechanical operations. It involved often grave and novel considerations, and it was his merit to bring to bear upon them accurate scientific knowledge and careful study. The lucid and skilful manner in which he was in the habit of applying scientific principles to his professional practice was well known to engineers generally: "Mr. Hawksley's formulæ," "Mr. Hawksley's data," "Mr. Hawksley's general results," and so on, were continually adopted as familiar guides by his professional brethren, and were quoted as authorities against which there could be no appeal.

On one occasion he had to advise on the drainage of one of the largest towns in the kingdom, and a question arose involving some artificial hydraulic conditions of much greater magnitude than usual. Doubts were expressed as to the feasibility of his scheme; but Mr. Hawksley had a strong impression that the ordinary rules, based on comparatively small experiments, did not apply. He accordingly examined the question thoroughly, bringing to his aid certain recent hydraulic researches by eminent French mathematicians; and, with the help of the writer of this notice, he succeeded in showing the practicability of the plan by an amount of scientific evidence which, while it was perfectly new, was absolutely incontrovertible.

Mr. Hawksley was President of the Institution of Civil Engineers for the years 1872 and 1873, and of the Institution of Mechanical Engineers in 1876 and 1877.

In 1876 he was elected President of the National Association of Social Science, holding their meeting at Liverpool, when he gave an address especially remarkable for its happy application of statistics to sanitation. He was a clever and lucid writer, and his keen appreciation of scientific reasoning gave weight to his opinions.

He was elected a Fellow of the Royal Society on June 6th, 1878, as being "especially distinguished for the application of Science to Hydraulic Engineering."

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Mr. Hawksley was blessed with a constitution which prolonged his life and energy much beyond the ordinary lot of man. In the beginning of September 1893, 63 years after his appointment as engineer to the Nottingham Waterworks, he undertook one of his customary tours of inspection of his works in progress in distant parts of England; but a fortnight afterwards he was attacked by a sudden and formidable disease, which his aged frame was not able to resist, and he died at his residence at Kensington on September 23rd.

He was elected a Fellow of this Society on January 22nd, 1866.

W. P.

George Mathews Whipple was born at Teddington in 1848, where his father at that time held the position of Master of the Public School. He was educated at the Grammar School at Kingston, and at the age of 15, in 1858, he was first engaged as a boy at the Kew Observatory, at which establishment he was connected for the rest of his life. He became Magnetic Assistant in 1862, and in 1876 was appointed Superintendent.

In discharge of his various duties in connection with that Observatory, Mr. Whipple became identified with the progress of most of the researches carried on there during the long space of 36 years. Among these we may specially mention the pendulum experiments made for the purposes of the Great Trigonometrical Survey of India, and the anemometer experiments at first commenced under Mr. Jeffery at the Crystal Palace, and later carried on with Mr. W. H. Dines at Horsham, the results of which have appeared in the Reports of the Wind Force Committee in the *Quarterly Journal*.

Mr. Whipple was the author of the magnetic portion of the Krakatoa Report.

He communicated several papers to the *Proceedings of the Royal Society*, and our own *Quarterly Journal* contains no less than 22 papers bearing his name either as sole or joint author.

He served on the Council from 1876 to 1887, for two years acting as Foreign Secretary. He was a B.Sc. of the London University, a Fellow of the Royal Astronomical Society, and an active Member of the Physical Society.

He died on February 8th, 1893, after a long and very painful illness, at the age of 50 years, and all who knew him mourn his loss as a thoroughly conscientious worker, a most courteous official, and a warm friend.

He was elected a Fellow of this Society on April 18th, 1874.

R. H. S.

APPENDIX V.

BOOKS PURCHASED DURING THE YEAR 1893.

Anderson, A. C.—The Dominion at the West, a brief description of the province of British Columbia, its climate and resources. 8°. (1872.)

B[urton], R.—The surprizing miracles of nature and art. 24mo. (1688.)

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COLLECTION of meteorological cuttings from the *Gentleman's Magazine*, *London Magazine*, and *Universal Magazine*, 1735 to 1758.

DAVY, J.—Notes and observations on the Ionian Islands and Malta. Two vols. 8°. (1842.)

ELIE, J. A. van.—Meteorologische Waarnemingen, gedaan voor de Maatschappij Felix Meritis, te Amsterdam. Van 1° Dec. 1849-1°Dec. 1852. F°. (1850-2.)

FRANÇOIS, R.—Essay des merveilles de nature, et des plus nobles artifices. Neufième édition. 8°. (1644.)

FULLER, A.—South Africa as a health resort. Second edition. 8°. (1889.)

GOODISSON, W.—A historical and topographical essay upon the islands of Corfù, Leucadia, Cephalonia, Ithaca, and Zante. 8°. (1822.)

HALL, C. R.—Torquay in its medical aspect as a resort for pulmonary invalids. 12°. (1857.)

HELLMANN, G.—Neudrucke von Schriften und Karten über Meteorologie und Erdmagnetismus. No. 1. L. Reynman. Wetterbüchlein von wahrer Erkenntniss des Wetters. 1510. Facsimiledruck mit einer Einleitung. 4°. (1898.)

————————.No. 2. Blaise Pascal. Récit de la Grande Expérience de l'Équilibre des Liqueurs. Paris, 1648. Facsimiledruck mit einer Einleitung. 4° (1898.)

HILLARY, W. Observations on the changes of the air, and the concomitant epidemical diseases in the Island of Barbadoes. 8°. (1759.)

HUGHES, S.—A treatise on Waterworks. New edition. 12°. (1875.)

HUMBOLDT, A. de—Asie Centrale. 3 vols. 8°. (1843.)

HUXLEY, T. H.—Physiography. 8°. (1890.)

INDEX GEOGRAPHICUS; compiled specially with reference to Keith Johnston's Royal Atlas. 8°. (1864.)

KEBBELL, W.—The climate of Brighton. 12°. (1859.)

L'ASTRONOMIE, 1893. 8°. (1893.)

LAWSON, H.—A paper on the arrangement of an observatory for practical Astronomy and Meteorology. 8°. (1844.)

[M————, J. R.]—A companion to the Anglo Chinese Kalendar, 1882. 8°. (1882.)

MACNAB, J.—Catechism of the Law of Storms for the use of sea officers. New and enlarged edition. 8°. (1890.)

MADDEN, T. M.—On change of Climate. 8°. (1864.)

MATHER, I.—An essay for the recording of illustrious Providences. 8°. (Library of Old Authors. Reprint.)

METCALFE, S. L.—Caloric. In 2 vols. 8°. (1843.)

METEOROLOGICAL REGISTER kept in Sussex (probably at or near Petworth), June 1772 to June 1778. F°. (MS.)

NEW BRUNSWICK, ST. JOHN, BOARD OF TRADE.—Report of the Special Committee on the Bay of Fundy and Harbor of St. John, N.B. 8°. (1887.)

OFFICIAL YEAR BOOK OF THE SCIENTIFIC AND LEARNED SOCIETIES of Great Britain and Ireland, 1893. 8°. (1893.)

PEEL, W.—A ride through the Nubian Desert. 8°. (1852.)

SMOLLETT, T.—Miscellaneous works. Vol. V. 8°. (1800.) [Contains a register of the weather at Nice, Nov. 1763 to March 1765.]

VINCE, S.—An account of a very remarkable Waterspout at Ramsgate in the afternoon of July 16, 1810. 4°. (1815.)

WALDO, F.—Modern Meteorology. 8°. (1893.)

WHISTLECRAFT, O.—Meteorological Journals kept at Thwaite, 1827-1892. 24 vols. (MS.)

APPENDIX VI.

DONATIONS RECEIVED DURING THE YEAR 1893.

Presented by Societies, Institutions, &c.

ADELAIDE, OBSERVATORY.—Meteorological Observations made at the Adelaide Observatory and other places in South Australia and the Northern Territory, 1881-5 and 1890.—Rainfall in South Australia and the Northern Territory, Aug. 1892 to July 1893.

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ALLAHABAD, METEOROLOGICAL OFFICE.—Annual statement of Rainfall in the North-Western Provinces and Oudh, 1892.

BARBADOES, COLONIAL SECRETARY'S OFFICE.—Returns of Rainfall in Barbadoes, Dec. 12, 1892, to Dec. 3, 1893.

BATAVIA, MAGNETICAL AND METEOROLOGICAL OBSERVATORY.—Observations, 1891.—Rainfall in the East Indian Archipelago, 1891.

BERLIN, DEUTSCHE METEOROLOGISCHE GESELLSCHAFT.—Meteorologische Zeitschrift, Dec. 1892 to Nov. 1893.

BERLIN, GESELLSCHAFT FÜR ERDKUNDE.—Verhandlungen, Band XIX. No. 9 to Band XX. No. 7.—Zeitschrift, Band XXVII. No. 4 to Band XXVIII. No. 3.

BERLIN, KÖN. PREUSS. METEOROLOGISCHES INSTITUT.—Bericht über die Thätigkeit, 1891 and 1892.—Ergebnisse der Beobachtungen an den Stationen II. und III. Ordnung 1893.—Ergebnisse der meteorologischen Beobachtungen, 1892, Heft 2.—Ergebnisse der Niederschlags-Beobachtungen, 1891.

BOMBAY, METEOROLOGICAL OFFICE.—Brief Sketch of the Meteorology of the Bombay Presidency, 1891-3.

BOSTON (MASS.), BLUE HILL OBSERVATORY.—Measurements of cloud heights and velocities; by H. H. Clayton and S. P. Fergusson.—Observations, 1891.

BOSTON (Mass.), NEW ENGLAND WEATHER SERVICE.—Bulletin, Dec. 1892 to Nov. 1893.

BREMEN, METEOROLOGISCHE STATION.—Ergebnisse der meteorologischen Beobachtungen, 1891.

BRISBANE, CHIEF WEATHER BUREAU.—Meteorological Report, 1888-91.—Notes on some of the more common diseases in Queensland in relation to atmospheric conditions, 1887-91, by Dr. D. Hardie.—Summaries of rainfall in Queensland, Oct. 1891 to Sept. 1892.

BRISBANE, GENERAL REGISTER OFFICE.—Annual Report by the Registrar General of Queensland, 1892.—Report on the vital statistics, Nov. 1892 to Sept. 1893.

BRISBANE, QUEENSLAND BRANCH OF THE ROYAL GEOGRAPHICAL SOCIETY OF AUSTRALASIA.—Proceedings and Transactions, Vol. VIII., 1892-3.

BRUSSELS, ACADÉMIE ROYALE.—Annuaire, 1892-3. Bulletins, Tomes XXII.-XXV., 1891-3.

BRUSSELS, INSTITUT NATIONAL DE GÉOGRAPHIE.—Bulletin Météorologique, Dec. 1892 to Nov. 1893.

BRUSSELS, OBSERVATOIRE ROYAL DE BELGIQUE.—Annales. Observations météorologiques d'Uccle, June to Dec. 1892.—Annuaire, 1893.

BUDAPEST, K. UNG. CENTRAL-ANSTALT FÜR METEOROLOGIE UND ERDMAGNETISMUS.—Jahrbuch, 1890.

BUKHAREST, INSTITUT MÉTÉOROLOGIQUE DE ROUMANIE.—Annales, 1890.—Buletinul Observatiunilor Meteorologice din Romania, Aug. and Dec. 1892, and Jan. to Nov. 1893.—Resumé des Observations Météorologiques de Bukharest (Filaret) pour 1890, et pour la période de 1885-90, par S. C. Hepites.

CAIRO, SOCIÉTÉ KHÉDIVIALE DE GÉOGRAPHIE.—Bulletin, IIIe Série, Nos. 11 and 12.

CALCUTTA, METEOROLOGICAL DEPARTMENT OF THE GOVERNMENT OF INDIA.—Cyclone Memoirs, No. 5. Account of the three cyclones in the Bay of Bengal and Arabian Sea during Nov. 1891, by J. Eliot.—Daily Weather Charts of the Indian Monsoon Area, Jan. 1 to July 17, 1893.—Indian Daily Weather Reports, Dec. 5, 1892, to Dec. 3, 1893.—Indian Meteorological Memoirs, Vol. IV. part 8, and Vol. V. parts 2 and 3.—Memorandum on the snowfall in the mountain districts bordering Northern India and the abnormal features of the weather in India during the past five months [Jan. to May], with a forecast of the probable character of the South-west Monsoon rains of 1893.—Monthly Weather Review, June 1892 to July 1893.—Rainfall data of India, 1891 and 1892.—Registers of original observations, reduced and corrected, June 1892 to July 1893.—Reports on the Administration of the Meteorological Department of the Government of India, 1891-3.—Report on Calcutta Cyclone of Oct. 5, 1864; by Lieut.-Col. J. E. Gastrell and H. F. Blanford.

CAPE TOWN, METEOROLOGICAL COMMISSION.—Report, 1892.

CHEMNITZ, KÖNIGL. SÄCHSISCHES METEOROLOGISCHES INSTITUT.—Das Klima des Königreiches Sachsen. Hefte 1 and 2.—Ergebnisse der meteorologischen Beobachtungen, 1892, I. Hälfte.—Jahrbuch, 1891, part 3, and 1892, part 3.

CHRISTIANIA, NORSKE METEOROLOGISKE INSTITUT.—Jahrbuch, 1891.—Nedborhoiden i Norge, beregnet efter observationer 1867 til 1891 af det Meteorologiske Institut.

COLOMBO, SURVEYOR GENERAL'S OFFICE.—Report on the Meteorology of Ceylon, 1892.

COPENHAGEN, DANSKE METEOROLOGISKE INSTITUT.—Bulletin Météorologique du Nord. Dec. 1892 to Oct. 1893.—Meteorologisk Aarbog, 1890, part 2, and 1892, part 1.

CORDOBA, ACADEMIA NACIONAL DE CIENCIAS.—Boletin, Tomo X., part 4, and Tomo XI., part 4.

CRACOW, K. K. STERNWARTE.—Meteorologische Beobachtungen, June 1892 to July 1893.

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CROYDON, MICROSCOPICAL AND NATURAL HISTORY CLUB.—Daily Rainfall in the Croydon district, Dec. 1892 to Oct. 1893.—Report of the Meteorological Sub-Committee for 1892.

DORPAT, OBSERVATORIUM.—Meteorologische Beobachtungen, 1892.

DUBLIN, GENERAL REGISTER OFFICE.—Annual Report of the Registrar-General (Ireland), 1891.—Weekly Returns of Births and Deaths, 1893.

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SYMONS, G. J.—British Rainfall, 1892.—Symons's Monthly Meteorological Magazine, 1893.

TAYLOR AND FRANCIS, MESSRS.—Taylor's Calendar of the Meetings of the Scientific Bodies of London for 1893-4.

TEISSERENC DE BORT, L.—Report on the present state of our knowledge respecting the general circulation of the atmosphere.

TYRER, R.—Meteorology of Cheltenham in 1892.—Rainfall in Gloucestershire, Jan. to Nov. 1893.

VERY, PROF. F. W.—Hail Storm of May 20, 1893.

WALKER, A. O.—The Climate of the North Coast of Wales.

WALLER, J. G.—Annual Report on the Health, Sanitary Condition, etc., of Woolwich, 1892. By Dr. W. R. Smith.

WARD, R. de C.—Thunderstorms in New England during the years 1886-7.

WATSON, REV. J.—Meteorological observations taken at Guisborough, Jan.-Apr. 1893. (MS.)

WATTS, F.—Meteorological Record for 1892 in Antigua.

WELLS, J. G.—The weather of 1891 at Burton-on-Trent.

WILD, DR. H.—Die Normal barometer des physikalischen Central-Observatoriums zu St. Petersburg.—Ueber die Darstellung des täglichen Ganges der Lufttemperatur durch die Bessel'sche Interpolationsformel.—Ueber Unsicherheiten in den Regnault'schen

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Spannkräften des Wasserdampfes unterhalb 100° und daraus entspringende Differenzen der Correctionen von Siedethermometern je nach ihrer Verificationsart.—Zusammenstellung der Beschlusse der internationalen Meteorologen-Conferenzen von der Conferenz in Leipzig, Aug. 1872 bis und mit der Conferenz in München, Aug. 1891.

WILMHURST, A. J.—Temperature and Rainfall at Manor Park, Essex, Dec. 1892 to Nov. 1893 (MS.).

WOOND, B. T.—Charts from a Richard barograph at Conyngham Hall, Knaresboro', 1892 (MS.).

APPENDIX VII.

REPORTS OF OBSERVATORIES, &c.

THE METEOROLOGICAL OFFICE.—Lieut.-Gen. R. Strachey, R.E., C.S.I., F.R.S., Chairman of Council; Robert H. Scott, M.A., F.R.S., Secretary; Nav. Lieut. C. W. Baillie, F.R.A.S., Marine Superintendent.

MARINE METEOROLOGY.—*Current Charts for all Oceans.*—In the last Memorandum appearing in this Report for the year 1892, it was stated that a considerable amount of information, some 25,000 observations in all, had been obtained from foreign authorities, in order to supplement the records of currents derived from English sources of information.

During the year now under review a further instalment of some 2,000 observations for the Pacific Ocean has been obtained from Germany, exhausting their data, and the Council are of opinion that they have now procured nearly all the trustworthy current observations in existence, at least in the archives of the various meteorological bureaus in Europe. The very anxious task of generalising the contents for publication must now be undertaken.

The Red Sea.—These charts are passing through the press. The twelve Monthly Wind Charts have all been signed for press, and the twelve Current Charts are now in an advanced stage.

The Meteorology of the South Sea.—This investigation has made steady progress during the year, but none of the final charts have as yet been placed in the engraver's hands.

The South Atlantic.—The preparation of logs and extraction of data for this district is being actively prosecuted. It will be understood that, as in the South Sea, the southern limit of the area to be discussed is given by the northern limit of the South Polar Ice.

A new edition of the *Barometer Manual for Seamen* is in hand.

WEATHER TELEGRAPHY.—The only change in the operations of this branch has been the abandonment of Mullaghmore as a station, owing chiefly to the difficulty of replacing satisfactorily the observer who died in the spring of 1893. There is an idea of establishing a station on Barra, in the Hebrides, but apparently the island is so hilly that wind reports would not be quite satisfactory.

The Office has since Michaelmas been in receipt of daily reports from Punta Delgada, in the Azores, through the kindness of Admiral de Brito Capello, of Lisbon, and of the Eastern Telegraph Company.

The Rain Tables for the decade 1881-90 are now in hand, and it is hoped that these will furnish information more complete, as to uniform geographical distribution of the stations, than anything which has yet appeared.

LAND METEOROLOGY OF THE BRITISH ISLANDS.—The volume of *Hourly Mean Readings for five-day periods for the Four Observatories* has been published for the year 1890, and that for 1891 is well advanced. The volume of *Observations from Stations of the Second Order* for 1889 is out, and that for 1890 may be expected in the course of the summer.

Mr. Dines' pressure tube anemometer has now been in operation on the roof of the Office for a year. Very interesting records have been obtained from it, especially during the storm of November 18th.

The records of bright sunshine for the seven observatories in connection with the Office have been tabulated hourly for the twelve years 1881-1892, and the results will be published with the hourly means for 1891.

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A new edition of the *Instructions in the use of Meteorological Instruments*, now 19 years old, is in preparation, to bring the book more up to the present state of Meteorology.—*February 15th*, 1894.

ROYAL OBSERVATORY, GREENWICH.—W. H. M. Christie, M.A., F.R.S., Astronomer Royal.

The usual routine meteorological work has been maintained with regularity during the year 1893. The only important instrumental change made in the year is the additional gearing which has been applied to the driving clock of Osler's Anemometer, by means of which the recording sheet can, when desired, be made to travel twelve times as fast. This arrangement has been brought into use on many occasions for the registration of high winds with the utmost benefit, the variation in pressure being much better seen than with the ordinary time scale. Portions of the working parts of Robinson's Anemometer which appeared to be much worn, have been recently renewed. It is satisfactory, however, to note that an independent comparison made (shortly before the renewal of the worn parts) by Mr. C. Harding, of the Meteorological Office, of the results recorded by this instrument in the gales of November last with those recorded by the anemometer of the Kew Observatory, indicated that these instruments were then giving practically identical results.

The discussion of the observations of the temperature of the air throughout the 50 years 1841-1890 has been completed, and the abstracts are partly printed. Various interesting particulars, relating to extremes, &c., have been extracted from these voluminous tables, but have not yet been finally brought into shape for printing. The results of the magnetical reductions 1865-1882 mentioned in last year's report are not quite ready for press.

The close of the year was marked by the retirement of Mr. Ellis, after a long and honourable term of service in the Royal Observatory, extending through 50 years, 20 of which had been spent as Superintendent of the Magnetical and Meteorological Department. The loss of Mr. Ellis to the public service will be severely felt. Mr. W. C. Nash has been promoted to succeed him as Superintendent, and the vacancy thus caused has not yet been filled up.—*March 12th*, 1894.

ROYAL OBSERVATORY, EDINBURGH.—Ralph Copeland, Ph.D., F.R.A.S., Astronomer Royal for Scotland.

At the end of the first quarter of 1893 the preparation of the monthly and quarterly summaries of weather observations of 55 Scottish stations for the use of the Registrar-General for Scotland was transferred from the Edinburgh Royal Observatory to the Scottish Meteorological Society, by whose members the observations are made.

The daily meteorological readings at the Observatory have been continued, together with the observations of the rock thermometers. The old rain gauge on the roof, at a short distance to the south of the dome, caught some 30 per cent. less rain than a similar gauge on the grass 22 feet lower down; this is quite in accordance with previous experience.

The removal to Blackford Hill, which will probably be carried out about the close of the year, will afford an opportunity of commencing a fresh series of observations, in which self-recording instruments will be largely used. In particular it is expected that the records of wind at the new Observatory will be of special interest.—*February* 1894.

KEW OBSERVATORY OF THE ROYAL SOCIETY, RICHMOND, SURREY.—Charles Chree, M.A., Superintendent.

It is with deep regret that the Committee have to report the decease of the late Superintendent, Mr. G. M. Whipple, B.Sc., which occurred on February 8th, after a serious illness of more than seven months. He had been connected with the Observatory in various capacities for thirty-four years, and had filled the

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office of Superintendent since 1876. Under his efficient management the work at the Observatory had been largely augmented in amount and variety, and the funds at its disposal for purchase of apparatus and extension of its premises had steadily increased.

During the earlier part of the year the work of the Observatory was carried out by Mr. Baker, the Chief Assistant, to the entire satisfaction of the Committee. They desire that his services should be specially recorded, and they are glad to state that the routine work of the Observatory has in no way suffered owing to the enforced absence of the Superintendent for the early months of the past year.

The Committee, having invited applications for the vacant post of Superintendent, selected from amongst the candidates Mr. Charles Chree, M.A., Fellow of King's College, Cambridge, Sixth Wrangler 1883, First Division Part III. of the Mathematical Tripos, and First Class in Part II. of the Natural Sciences Tripos, 1884. Mr. Chree entered on his duties on May 15th.

The self-recording instruments for the continuous registration of atmospheric pressure, temperature of air and wet-bulb, wind (direction and velocity), bright sunshine, and rain, have been maintained in regular operation throughout the year, and the standard eye observations for the control of the automatic records duly registered.

The "Willesden" prepared papers have been in daily use on the self-recording Beckley gauge, and although the curves obtained are clear and distinct, yet the defect of the lengthening of the sheets in wet weather has not been entirely overcome. Circular letters were sent to several prominent paper makers asking for samples of material, specially prepared, to be used in a very damp atmosphere; but of those obtained, only one sample (supplied by Messrs. Waterlow and Sons) showed no appreciable lengthening in the dampest atmosphere producible artificially. It has, however, some counterbalancing defects, which render its superiority to the Willesden paper for the purpose in view somewhat doubtful.

At the request of the Meteorological Office an investigation has been carried out as to the causes of fluctuations that present themselves in the value of the residual correction to barograph readings, which is deduced by comparison of simultaneous readings of the barograph and a standard barometer. An analysis was made of the value of the residual correction between May 1892 and October 1893, while numerous measurements were taken of the width of the temperature compensation to the barogram at different temperatures. The data obtained accounted for a very considerable part, at least, of the irregularities observed in the residual correction. A report embodying an analysis of the results has been sent to the Meteorological Office.

The electrograph has been in regular action during the year, but its performance on the whole has been rather unsatisfactory. Early in the year the needle-suspension being accidentally broken, another was fitted without delay, and a new determination made of the scale value. Subsequent re-determinations were carried out in May, July, and November. It is intended to take advantage of the first spell of frosty weather to dismount and thoroughly overhaul the instrument, and to open out the scale, which has for some time past been too contracted.

Operations connected with cloud photography have been suspended during the year.

The observation of a series of distant objects referred to in the last report has been continued. A note is taken of the most distant of the selected objects, which is visible at each observation hour. An analysis of the results for the period May 1892 to December 1893 is at present being carried out. During the thickest fog experienced in the past year, at one of the hours of observation the most distant object visible was only 12 feet off.

The mean temperature of the air for the year was 50°·9, and the extreme range 75°·5, from 18°·1 on January 5th to 88°·6 on August 17th. In the sun's rays the maximum, 139°, occurred on June 19th, and the lowest reading of a thermometer freely exposed on the grass was 7° on January 5th.

The year was remarkable for the drought during the spring, and for the very large amount of bright sunshine recorded, no less than 1,681½ hours being registered, giving a mean percentage of 35, the highest yearly value yet obtained. With the exception of January, July, and November, each month was well above the average, the maximum record of 59 per cent. in April being 27 per cent.

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above the April mean for the past 16 years. The total rainfall was 19·50 ins.—*May* 1894.

RADCLIFFE OBSERVATORY, OXFORD.—E. J. Stone, F.R.S., Radcliffe Observer.

No change in the routine or staff has been made during the year. The Robinson Anemograph, having become much worn during the 18 years it had been mounted on the Observatory Tower, was replaced in July 1893 by a new one, which includes all the latest improvements, and is working well.

The other self-recording instruments have been working satisfactorily during the year. The gelatino-bromide paper is used for the photographic registers, and gives excellent results.

Eye readings have been taken as usual; and reports sent daily by telegram to the Meteorological Office, monthly to the Registrar-General and local press.

The following are the chief characteristics of the weather noted at Oxford during the year 1893:—

There was a remarkable absence of rain during the spring months; from March 4th to May 15th only 0·016 in. was registered at this Observatory. In June only one-third of the average amount fell, whilst August and September were much below the average: July, however, was 1·3 in. in excess of the average.

The total rainfall for the year was 18·596 ins., or 8 inches below the average for the preceding 78 years.

As regards temperature, the early part of January was marked by continued frost, with a minimum in the air on the 5th of 12°·9, and on the grass 7°·1; the average for the month being 2°·5 below the mean for the preceding 38 years. During the remaining months of the year, with the exception of November, the mean monthly temperatures were all high; those of March, April, May and August being respectively 4°·8, 5°·3, 4°·5, and 4°·1 above the average for the preceding 38 years. The maxima were 84°·3, 85°·7, 85°·6, 88°·1, and 88°·3 on the five consecutive days of August 14th, 15th, 16th, 17th and 18th.

Coincident with the defect of rainfall and excess of temperature, the excess of recorded bright sunshine was a marked feature of 1893, there being 365 hours recorded above the average for the last 13 years.—*January 22nd*, 1894.

REPORT ON THE
PHENOLOGICAL OBSERVATIONS FOR 1893.

By EDWARD MAWLEY, F.R.Met.Soc., F.R.H.S.

(Plate II.)

[Read February 21st, 1894.]

THE number of observers sending in returns during 1893 was 117, showing a slight increase on the two previous years. The changes in the observing stations have been as follows:—No returns were received from Whitchurch Canonicorum, Tunbridge Wells, Canterbury, Beckenham, and Henley-on-Thames in District C.; Burton-on-Trent and Huddersfield in District D.; Chester, Settle, and Douglas (Isle of Man) in District F.; and Collon in District G. On the other hand, observations were sent in from the following new stations;—Mawnan Smith, West Bagborough, and Long Ash-

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ton in District **A.**; Bembridge, (Isle of Wight), Bidborough, Swanley, Chislehurst, Bickley, Cranleigh, Ashtead, Croydon, Farley, and Whatley in District **C.**; Watford and Broxbourne in District **D.**; Ashwell in District **E.**; Penmaenmawr, and Cronkbourne and Sulby (Isle of Man) in District **F.**; and Cambois in District **I.**

All the eleven Districts are represented, but there are still only two observers in Ireland South (District **B.**), and but one observer in either Scotland East (District **J.**) or Scotland North (District **K.**). More observers in these three Districts are much needed, in order that they may be placed on something like an equal footing with the others. Returns from one or two stations only, which may chance to be either very exposed or sheltered, as the case may be, must necessarily represent but indifferently the climate of any considerable portion of our Islands.

The observations regarded as a whole are the best I have yet had the pleasure of tabulating, and the thanks of the Society are due to the Phenological Observers generally for sending in so many valuable and interesting returns. Not only have the observations been as a rule more carefully made than in the two previous years, but they are also more numerous. For instance, where the returns from the different stations contained on an average the dates of flowering of 8 of the 13 plants in 1892, there were to be found 9 entered in 1893.

The Winter of 1892-93.

December, taken as a whole, was a cold winter month, except in the south of Ireland, where the mean temperature comes out as slightly above the average. January also proved unseasonably cold, especially in the southern, eastern, and south-western districts of England, where the departures from the mean amounted to $-5°{\cdot}0$, $-4°{\cdot}5$, and $-3°{\cdot}8$ respectively. February, on the other hand, was mild in all the divisions—and very wet.

Until the middle of the fourth week in December the weather remained for the most part mild and dry throughout the greater part of the British Isles. In the warmer districts garden flowers were here and there to be seen in blossom until within a few days of Christmas, and at Scilly the first small gathering of daffodils was made shortly after the middle of the month. Then came four weeks of continued frost, which brought everything suddenly to a standstill, and penetrated the soil to an unusual depth, owing to the absence in most places of any covering of snow worth mentioning. The soil and atmosphere remaining unusually dry for the season, less injury was done to half-hardy vegetation generally than in previous winters when the cold was less intense and prolonged. In gardens vegetables appear to have suffered the most, particularly the more tender kinds, such as broccoli, celery, cauliflowers, &c. This proved a trying period for birds, and many perished from cold, and through their natural supply of food being cut off for weeks together, owing to the frozen state of the ground. Scarcely had the long frost broken up than winter aconites and other early flowers began to make their appearance in the south of England, showing how complete

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the change in temperature must then have been. From this time until the end of the season mild and wet weather prevailed.

This winter quarter was by no means a favourable one to the farmer. The long continued frost not only kept the plough idle for weeks together, but also committed sad havoc among the turnips. Then again, the soil was so saturated by rain during February that any but light lands were rendered as unworkable as before.

The hazel came into flower later than its adopted average in all districts—the departures from the mean being smallest in the southern, midland, and eastern counties of England, and greatest in Ireland North, Scotland, and the north of England. The dates of flowering of the coltsfoot were as usual very irregular, but in most districts also rather later than the average. No doubt the great depth to which the long frost penetrated the ground in January helped to retard the blossoming of these two plants.

The song of the thrush was first heard a few days earlier than in either 1891 or 1892. The honey-bee first visited flowers about the same dates as in 1891, but a little earlier than in 1892.

The Spring.

This proved by far the most remarkable season of this remarkable year. In each of the three months the mean temperature was in every district considerably above the average—the departures for the quarter ranging from $+2°{\cdot}6$ in England North-east and in Scotland North, to $+4°{\cdot}4$ in the south-west of England. The total rainfall was much in defect of the mean—ranging from $-2{\cdot}1$ ins. in the north of Scotland to $-5{\cdot}8$ ins. in England South-west. The record of sunshine, too, if we omit Scotland and the north of Ireland, proved equally exceptional. In fact, in the south-western, southern, and midland counties of England the aggregate duration exceeded the mean by more than 200 hours.

Taking the British Isles as a whole, the most noteworthy feature of this season was its very exceptional earliness. Stimulated by the continued heat, vegetation of all kinds was everywhere forced on rapidly, and without any check worth mentioning, into leaf and flower, and in some cases into fruit, long in advance of its usual time. Even in parts of Scotland strawberries were gathered in May and new potatoes and peas ready for use.

Throughout nearly the whole of England, however, a persistent drought reigned supreme, and was there perhaps even more exceptional in its effects than the unseasonable warmth of the ground and atmosphere. In fact, until after the middle of May there did not occur a single week in which the fall of rain was not much below the average. Owing no doubt to the abundant rainfall in February, and the genial weather which followed, the trees in no way suffered. On the contrary, the general remark at the time seems to have been that their foliage appeared singularly abundant and well developed. Rarely have flowering trees and shrubs been seen to bloom so freely. Fruit trees especially were densely covered, but were soon out of blossom. The injurious influence of the drought upon the less deeply rooted plants was,

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however, very marked. The fields and hedge-rows became unusually gay with spring and summer flowers, following each other in rapid succession after the middle of the season, but the dry and forcing weather soon told upon the plants themselves, stunting their growth, and causing their blossoms to fade before they were at their best.

After the middle of March the land was in splendid condition for getting in the spring corn, which has seldom had so favourable a seed bed. But in many instances the ground had become so dry that the grain failed to germinate at all, or came up very irregularly, and not until weeks, and sometimes months, after it had been sown. Garden seeds also germinated very slowly. The pastures were remarkably bare, and the farmers often at their wit's ends to provide sufficient fodder for their cattle and sheep.

But, after all, it should be borne in mind that many of the foregoing remarks only apply to about one half the area of the United Kingdom. For in some of the northern counties of England, as well as throughout Scotland and a great part of Ireland, there has scarcely ever been known a more favourable spring for crops of all kinds. For although the weather continued also unseasonably dry in these favoured districts, it was never injuriously so. For one thing, what is called a drought in the wetter parts of our islands is by no means so serious a matter as where the average rainfall is lighter, but last year these parts also appear to have been visited by heavy showers just at the times when they were becoming most needed by the growing crops.

I am unable to account satisfactorily for the wood anemone flowering so late as it did in many districts in such a warm March, unless it be that growing under the shelter of trees in shady spots the brilliant sunshine had not the same power in raising the temperature of the soil as where the ground had been fully exposed to its influence. In the south-west of England, as well as in some of the northern counties, it was three weeks behind the adopted mean. The blackthorn, on the other hand, bloomed from about a week to ten days in advance of the average dates, while garlic hedge mustard was in most districts about a fortnight earlier than usual. The horse chestnut was as a rule about three weeks in advance of the mean. The hawthorn was also about three weeks early, the white ox-eye about a fortnight early, while the dog rose flowered fully three weeks in advance of the average in several districts. At Marlborough the first flower of the hawthorn was noted on April 15th, which is not only 29 days earlier than its average for that station in the preceding 28 years, but 15 days earlier than in any of them. The white ox-eye also blossomed 6 days earlier than the earliest, and the dog rose 11 days in advance of the previous earliest record.

Three of the spring migrants on the list, the swallow, the cuckoo, and the nightingale, according to the returns, made their appearance in this country about a week earlier than in either of the two previous years. The flycatcher also arrived a trifle earlier than in 1892.

The wasp, the small white butterfly and orange tip butterfly were first seen from a fortnight to three weeks in advance of their average records for the two previous springs.

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The Summer.

This was not nearly so abnormal a season as the one preceding it. Throughout June and the greater part of August the weather remained extremely warm, dry, and sunny, but in July, after the first week, the temperature was somewhat below the mean for the month, while the rainfall was for a time moderately heavy.

In England the memorable drought of 1898 may be said to have lasted 18 weeks—*i.e.* from the beginning of March until the end of the first week in July. During this period there occurred but one week, the third in May, when the rainfall was not below, being generally much below, the average.

On dry soils the lime trees began shedding their leaves before the end of June, and by August their foliage had become quite yellow. The hay crop, where gathered, proved one of the lightest on record, but was harvested in capital condition. The pastures also were so burnt up by the heat that the cattle and sheep suffered greatly, and in many parts of the country had to be turned into the growing corn. In the gardens vegetables made but poor growth, peas especially being in most places the worst failure. On the other hand, in some of the northern counties of England, as well as throughout Scotland and a great part of Ireland, both farm and garden crops appeared to appreciate the unusual warmth and were singularly luxuriant, owing to the timely arrival of copious rains whenever the ground was beginning to get, in any way, injuriously dry. In all parts of the British Isles trees, shrubs, and plants of all kinds came into bloom and fruit remarkably early. Indeed, many autumn flowers were out of blossom before the autumn began. The harvest, too, was remarkably early, being practically over by the end of the third week in August throughout the southern and midland counties of England.

The crop of strawberries, in all but the south-western and north-western divisions of England, and in Scotland, where it was about average, was a very poor one. Bush fruits, on the contrary, were everywhere unusually abundant.

The welcome and refreshing rains of July soon made themselves felt, and particularly in the improved appearance of the pastures, but the beneficial effect gradually passed away when they were over, so that by the end of the summer the grass fields in most parts of England had become as bare and brown as before.

The continued heat and sunshine proved favourable to insect life. For instance, as the observers' returns show, wasps were so numerous in many counties in England as to amount to a plague. Butterflies too are reported to have been singularly abundant, and the comparatively rare clouded-yellow butterfly again appeared rather frequently in many localities, but not, however, in such numbers as in 1892. The humming-bird-hawk moth was also noted as unusually abundant in the south and south-west of England, as well as in some of the midland counties.

The black knapweed flowered more than three weeks earlier than its average

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TABLE I.—LIST OF OBSERVERS.

	Station.	County.	Height above sea-level.	Observer.
	A.		Ft.	
1	Marazion	Cornwall	40	F. W. Millett
2	Mawnan Smith	Cornwall	200	Miss R. Barclay
3	Falmouth	Cornwall	190	Miss Willmore
4	Liskeard	Cornwall	400	S. W. Jenkin, C.E.
5	Tiverton	Devon	270	Miss M. E. Gill
6	Westward Ho	Devon	100	H. A. Evans
7	Instow	Devon	250	H. M. W. Hinchliff
8	West Bagborough	Somerset	350	E. G. Aldridge, F.R.Met.Soc.
9	Sidcot	Somerset	200	W. F. Miller C. B. Rowntree
10	Long Ashton	Gloucester	280	Miss T. L. Dyke Miss H. Dawe
11	Clifton	Gloucester	300	G. C. Griffiths, F.E.S.
12	Penarth	Glamorgan	120	G. A. Birkenhead
13	Cardiff	Glamorgan	40	A. Pettigrew
14	Castleton	Glamorgan	80	F. G. Evans, F.R.Met.Soc.
15	Bassaleg	Monmouth	25	W. J. Grant
16	St. Arvan's	Monmouth	360	Miss Mabel Peake
17	St. David's	Pembroke	220	W. P. Propert, LL.D., F.R.Met.Soc.
18	Aberystwith	Cardigan	30	J. H. Salter, B.Sc.
	B.			
19	Killarney	Kerry	100	Ven. Archdeacon Wynne, F.R.Met.Soc.
20	Wicklow	Wicklow	10	Mrs. Wyndham Wynne
	C.			
21	Bembridge	Isle of Wight	80	C. Orchard
22	Blandford	Dorset	270	J. C. Mansell-Pleydell, F.G.S., F.L.S.
23	Buckhorn Weston	Dorset	290	Miss H. K. H. D'Aeth
24	Pennington	Hants	100	Miss E. S. Lomer
25	Strathfield Turgiss	Hants	200	Rev. C. H. Griffith
26	Bexhill-on-Sea	Sussex	10	H. Le Mesurier Dunn
27	Muntham	Sussex	250	Percy S. Godman, F.Z.S.
28	Dover	Kent	150	F. D. Campbell
29	Bidborough	Kent	420	Miss Mawley
30	Lynsted	Kent	140	R. M. Mercer, F.R.Met.Soc.
31	Farnborough	Kent	350	F. G. Minchin Kelly
32	Swanley	Kent	220	C. H. Hooper
33	Chislehurst	Kent	360	Miss F. Duncan
34	Bickley	Kent	300	Miss E. Scott
35	Coneyhurst	Surrey	600	J. Russell
36	Churt Vicarage	Surrey	350	Rev. A. W. Watson
36	Churt	Surrey	300	C. Criddle
37	Cranleigh	Surrey	180	Admiral J. P. Maclear, F.R.Met.Soc.
38	Winterfold	Surrey	580	R. Turvey
39	Willinghurst	Surrey	400	A. Nash
40	Oxshott	Surrey	210	W. H. Dines, B.A., F.R.Met.Soc.
41	Ashtead	Surrey	..	R. M. Prideaux
42	Addlestone	Surrey	100	C. U. Tripp, M.A., F.R.Met.Soc.
43	Croydon	Surrey	200	Miss Grahame
44	East Molesey	Surrey	40	Lady Jenkyns
45	Farley	Wilts	..	Miss F. C. Henderson
49	Salisbury	Wilts	150	W. Hussey
47	Marlborough	Wilts	480	E. Meyrick, B.A., F.Z.S.
48	Whatley	Somerset	450	C. G. Whittaker
49	Whitchurch	Oxford	150	Rev. J. Slatter, M.A., F.R.Met.Soc.
50	Reading	Berks	..	H. Goadby
	D.			
51	Oxford	Oxford	200	F. A. Bellamy, F.R.Met.Soc.
52	Cheltenham	Gloucester	250	M. L. Evans
53	Beckford	Gloucester	120	F. Slade, F.R.Met.Soc.

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TABLE I.—LIST OF OBSERVERS—*Continued.*

Station.	County.	Height above sea-level.	Observer.
D.		Ft.	
54 Watford	Herts	250	Mrs. G. Bishop
55 Broxbourne	Herts	150	Lady Frances Bushby
56 St. Albans (The Grange)	Herts	380	Mrs. Hopkinson
56 St. Albans (Addiscombe Ldg.)	Herts	400	Miss E. F. Smith
56 St. Albans (St. Peter's Street)	Herts	380	H. Lewis
56 St. Albans (Newberries)	Herts	320	H. Lubbock
57 Berkhamsted	Herts	400	Mrs. E. Mawley
58 Harpenden	Herts	370	J. J. Willis
59 Ross	Hereford	210	H. Southall, F.R.Met.Soc.
60 Breinton	Hereford	230	H. A. Wadworth, F.R.G.S.
61 Evesham	Worcester	120	Rev. D. Davis, B.A.
62 Henley-in-Arden	Warwick	320	T. H. G. Newton, F.R.Met.Soc.
63 Northampton	Northampton	320	H. N. Dixon, M.A., F.L.S.
64 Churchstoke	Montgomery	550	P. Wright, F.R.Met.Soc.
65 Burbage	Leicester	430	C. C. Hurst, F.R.H.S.
66 Thurcaston	Leicester	250	Rev. T. A. Prestou, F.R.Met.Soc.
67 Uppingham	Rutland	300	G. W. S. Howson, M.A.
68 Walsall	Stafford	450	W. F. Blay, F.R.Met.Soc.
69 Tean	Stafford	470	Rev. G. T. Ryves, F.R.Met.Soc. Miss G. M. B. Ryves
70 Beeston	Notts	210	G. Fellows, F.R.Met.Soc.
71 Hodsock	Notts	60	Miss Mellish, F.R.H.S.
72 Eaton	Notts	..	J. Cordeaux
73 Bakewell	Derby	400	Miss E. Taylor
74 Macclesfield	Cheshire	500	J. Dale
75 Belton	Lincoln	200	Miss F. H. Woolward
76 Harrogate	Yorkshire	340	J. Farrah
E.			
77 Hertford	Herts	140	W. Graveson
78 Hitchin	Herts	230	J. E. Little, M.A.
79 Ashwell	Cambridge	260	H. G. Fordham
80 Bocking	Essex	240	H. S. Tabor, F.R.Met.Soc.
81 Lexden	Essex	90	Miss Carver
82 Sproughton	Suffolk	30	Rev. A. Foster-Melliar
83 Tacolneston	Norfolk	190	Miss E. J. Barrow
84 Wryde	Cambridge	10	S. M. Egar
F.			
85 Heswall	Cheshire	160	F. M. Sherwood
86 Penmaenmawr	Carnarvon	350	A. T. Johnson
87 Claughton	Lancashire	80	Mrs. Kent Green
88 Giggleswick	Yorkshire	500	E. Peake, M.A.
89 Ambleside	Westmoreland	320	S. A. Marshall
90 Egremont	Cumberland	160	J. Sherwen
91 Cronkbourne	Isle of Man	110	A. W. Moore J. Murphy
92 Orry's Dale	Isle of Man	70	Miss C. G. Crellin
93 Sulby	Isle of Man	80	H. S. Clarke, F.E.S.
G.			
94 Edgeworthstown	Longford	270	J. M. Wilson, B.A.
95 Loughbrickland	Down	350	Rev. H. W. Lett, M.A.
96 Saintfield	Down	310	Rev. C. H. Waddell, M.A.
97 Antrim	Antrim	70	Rev. W. S. Smith
98 Londonderry	Londonderry	450	T. Gibson
99 Ballynagard	Londonderry	30	Miss A. M. Campbell

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TABLE I.—LIST OF OBSERVERS—*Continued.*

Station.	County.	Height above sea-level.	Authority.
H.		Ft.	
100 Dalshangan	Kirkcudbright	500	T. R. Bruce
101 Tynron	Dumfries	520	J. Shaw
102 Thornhill	Dumfries	300	J. Fingland
103 Jardington	Dumfries	100	J. Rutherford
104 Helensburgh	Dumbarton	100	Miss Muirhead
I.			
105 Doddington	Lincoln	90	Rev. R. E. Cole
106 Driffield	Yorks (E. R.)	80	The late J. Lovel, F.R.Met.Soc.
107 Thirsk	Yorks (N. R.)	120	A. B. Hall
108 East Layton	Yorks (N. R.)	570	Mrs. E. O. Maynard Proud
109 Durham	Durham	350	H. J. Carpenter
110 Low Fell	Durham	90	A. W. Price
111 Cambois	Northumberland	20	S. Dunnett
J.			
112 Aberdeen	Aberdeen	40	P. Harper
K.			
113 Inverbroom	Ross	50	J. A. Fowler

The numbers before the names of the Stations refer to their position on the map of the Stations, Plate II.

date in nearly all the English districts, but in England North-east, Scotland West, and Ireland North, the dates are about a week behind the adopted means. The harebell in most places blossomed from a week to three weeks earlier than usual. The greater bindweed, however, eclipsed all the other plants on the list as regards earliness, flowering as it did in nearly all parts of the country from a month to six weeks in advance of its usual time. At Marlborough, both the black knapweed and the harebell flowered in advance of the previous earliest record (1876-92).

The average date for the British Isles for the appearance of the meadow-brown butterfly was June 20th in 1891, and June 10th in 1892, whereas for 1893 it comes out as May 25th.

The Autumn.

Regarded as a whole, this was a cool, dry and sunny season. In September the temperature was about the average, in October somewhat above it, while November proved moderately cold throughout the month.

The second drought of the year began in England about the middle of August, and lasted in most districts seven weeks. This was again a most trying time for vegetation, indeed, more trying in many places than the previous drought owing to the greater dryness of the subsoil. Trees growing on porous lands consequently suffered much, and shed their leaves at an unusually early date. The pastures became as parched and brown as before, the growth of the root crops was checked, early apples and pears ripened prematurely, while comparatively few flowers were to be seen in the fields or gardens.

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From the time that this second drought came to an end until the close of the season, vegetable growths of all kinds made as rapid and complete a recovery as was possible so late in the year. The rainfall being sufficiently abundant, and the ground having been warmed to a considerable depth, the green appearance of the grass was revived as if by magic, so that farmers no longer wanted for keep for their cattle, while the growing roots rapidly increased in size. The land was in a most favourable condition for working, and the autumn corn got in under the most advantageous circumstances.

One of the most noteworthy features of this autumn was the number of trees and shrubs which flowered a second time, to say nothing of numerous herbaceous plants. This does not appear to have been confined to any particular district, but was common throughout the country. The most frequent instances reported were those of the dog rose, bramble, dogwood, apple, pear and horse-chestnut. This second flowering was no doubt due to the shoots of these trees and shrubs having ripened and rested during the drought and then started afresh into active growth when the rains came. To similar causes must be attributed the second fruiting of strawberries and raspberries which was almost as frequently noted. In order to give some idea of how quickly growths were made and matured during the summer, two instances may be quoted from the observers' notes. In one case sweet peas are stated to have flowered last autumn from plants which had come up from the ripened peas shed from the pods of the summer crop. In another, small dahlia plants were sent to me which had grown in a similar way from self sown seed. Fields, too, were to be seen in October gay with a second crop of poppies in full flower. Wild fruits of all sorts were especially abundant, and more particularly acorns. But only in certain parts of the country were holly berries in any numbers to be met with. In most places the autumn tints were fine, owing to the gradual maturing of the foliage.

The ivy was first noted as in flower in all the warmer parts of our Islands from 10 days to a fortnight earlier than usual, but throughout the colder districts was in most places less than a week in advance of the mean. At Marlborough the ivy came into flower earlier than in any previous year (1876-92).

The swallow appears to have taken its departure a few days earlier than in the previous year.

As regards the autumn fruit crops, apples proved almost everywhere about an average crop, pears a poor crop, while plums yielded abundantly. In many places, notwithstanding the continued drought, the individual fruits of both apples and pears often attained an unusual size. Most of the early and mid-season kinds, however, kept badly after gathering.

The harvest in all parts of the Kingdom began at a singularly early date. The wheat crop was much under average in the Southern and Eastern districts of England and about average in the Midlands, but elsewhere the yield proved as a rule good, and the same remarks apply fairly well to barley and oats. Beans and peas were much below average in nearly all districts. Potatoes, on the contrary, were almost everywhere a good and sound crop. Turnips and mangolds yielded indifferently, except in England North-west

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TABLE II.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1893.

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse Chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
A.													
Marazion	32	41	72	70	..	106	108	138	*117*	167	..	170	238
Mawnan Smith	..	..	..	..	..	96	113	131	129	164	..	184	244
Falmouth	36	41	88	67	..	104	110	130	133	148	..	155	..
Liskeard	35	53	89	75	107	104	111	..	130	..	..	..	..
Tiverton	34	56	79	81	95	105	107	..	..	..	..	..	268
Westward Ho	..	60	82	82	..	.	..	..	130	166	..	146	..
Instow	27	59	..	73	91	100	99	123	126	136	..	..	..
West Bagborough	..	..	..	..	94	95	110	117	128	134	..	..	..
Sidcot	..	50	71	87	94	99	111	119	130	..	..	..	
Clifton	..	..	84	87		99	110	130	128	..	..	..	..
Long Ashton	..	..	..	91	98	..	..	..	*145*	..	..	..	233
Cardiff	37	..	..	..	..	97	108	121	131	..	..	..	..
Castleton	33	46	67	74	91	91	110	124	129	146	184	141	231
Bassaleg	34	57	86	86	..	97	107	..	133	..	..	..	267
St. Arvans	30	64	68	88	98	108	112	130	134	..	..	164	233
St. David's	..	49	..	88	..	..	113	..	..	..	..	..	..
Aberystwith	27	56	80	77	88	111	105	109	131	146	168	160	242
B.													
Killarney	25	33	51	54	92	95	101	125	123	178	..	166	229
Wicklow	43	45	78	64	95	106	103	126	132	130	..	155	..
C.													
Bembridge	..	..	..	85	98	99	108	119	142	145	..	..	..
Blandford	27	63	71	83	100	110	111	116	136	145	192	*221*	*307*
Buckhorn Weston	36	48	77	84	92	110	108	119	129	135	..	136	249
Pennington	39	63	..	84	104	106	108	120	133	143	139	180	250
Strathfield Turgiss	38	65	67	89	98	109	114	123	134	140	135	143	263
Bexhill-on-Sea	45	..	71	88	109	102	109	133	144	..	..	..	290
Muntham	33	72	66	83	107	109	104	122	139	153	..	176	..
Dover	..	46	..	91	..	..	118	..	142	170	..	..	255
Bidborough	44	..	*104*	90	..	113	116	*146*	142	..	..	..	..
Farnborough	42	56	82	90	103	115	114	118	137	*191*	194	194	..
Swanley	33	59	86	..	111	..	117	..	..	..	185	..	..
Chislehurst	..	..	..	..	..	..	..	..	133	*192*	187	160	..
Bickley	..	..	81	90	109	111	113	138	142	..	..	..	..
Coneyhurst	39	67	73	87	120	125	116	128	121	..	170	196	*303*
Churt (Vicarage)	34	67	84	88	104	113	112	130	133	..	154	171	..
Churt	34	60	71	87	102	113	108	136	130	159	126	166	240
Winterfold	51	37	62	84	..	122	118	..	140	163	195	..	268
Willinghurst	33	..	79	..	..	109	106	..		..	..	..	259
Oxshott	43	..	76	85	..	..	..	127	137	162	..	175	..
Ashtead	39	63	75	89	103	114	121	131	..	..	..	..	..
Addlestone	48	61	85	88	105	112	112	130	138	150	193	157	..
Croydon	41	68	..	90	..	..	..	134	144	..	..	..	..
East Molesey	36	62	..	88	..	112	114	127	138	..	..	177	254
Farley	27	..	75	82	84	113	112	120	127	140	.	136	..
Salisbury	38	..	..	77	104	107	109	117	129	..	..	..	..
Marlborough	31	..	68	88	122	112	105	124	131	144	148	..	241
Whatley	39	..	..	..	99	104	116	127	..	160	*237*	*206*	..
Whitchurch	35	..	..	..	..	111	114	..	..	..	..	..	..
Reading	*62*	..	84	74	..	105	112	136	139	..	..	..	.
D.													
Oxford	..	..	..	..	95	102	110	..	135	142	..	..	253
Cheltenham	29	50	64	84	97	104	106	..	128	155	181	183	236
Beckford	35	64	70	83	100	108	108	117	125	143	161	154	236
Watford	37	*106*	*107*	86	103	114	112	*145*	144	..	..	..	..
Broxbourne	..	..	71	85	..	111	114	..	142	..	..	..	..

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TABLE II.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1893—*Continued.*

District and Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse Chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
D.													
St. Albans (The Grange)	36	..	72	87	100	105	113	130	133	..	..	..	242
St. Albans (Ad.Lge).	..	76	77	81	96	108	115	122	131	151	..	..	267
St. Albans (Newberries.....	..	..	79	87	109	111	117	130	136	..	..	..	..
Berkhamsted	36	57	83	88	94	117	114	131	130	149	191	146	252
Harpenden	20	61	86	90	94	114	112	129	137	156	..	152	..
Ross	50	..	..	78	..	..	109	..	136	..	..	..	..
Breinton	33	65	67	84	91	113	109	129	130	146	186	166	247
Evesham	48	60	81	82	103	105	104	122	124	167	..	147	269
Henley-in-Arden ..	31	67	77	85	..	107	111	125	124	148	..	..	..
Northampton	42	72	..	91	105	113	113	125	133	166	..	170	249
Churchstoke	39	61	77	85	99	112	118	130	140	..	..	..	..
Burbage	..	..	92	94	..	109	114	..	150	..	..	..	..
Thurcaston	..	..	84	90	96	115	109	131	139	139	..	..	..
Uppingham	37	60	72	85	98	..	108	126	131	145	..	..	..
Walsall	35	50	81	94	106	120	116	140	151	182	183	200	273
Tean	67	..	79	96	..	..	117	..	140	..	..	..	..
Beeston	30	39	..	89	..	114	114	141	147	158	..	..	..
Hodsock	24	65	80	84	104	113	113	143	141	176	188	163	253
Eaton	..	..	..	91	..	..	117	..	141	..	..	..	..
Bakewell	68	70	82	99	116	129	123	146	153	179	186	..	..
Macclesfield	59	87	95	106	..	115	116	144	149	182	185	187	269
Belton	21	67	72	..	113	116	111	131	136	162	..	183	261
Harrogate	34	51	88	99	104	120	128	151	150	165	194	179	268
E.													
Hertford	36	50	71	68	90	113	106	131	139	151	187	148	253
Hitchin	35	48	69	83	96	115	106	129	133	138	..	169	247
Ashwell	..	..	..	87	..	..	110	..	133	..	..	..	..
Bocking	30	48	88	92	108	109	119	137	135	*188*	..	190	226
Lexden	46	..	..	87	..	99	113	..	..	..	..	..	..
Sproughton	29	..	73	93	110	112	118	124	135	..	..	..	260
Tacolneston	32	71	..	..	..	100	..	..	..	157	..	..	245
Wryde	60	61	79	84	..	114	113	..	..	..	..	..	..
F.													
Heswall	..	42	..	99	..	109	86	135	*133*	..	..	..	..
Penmaenmawr	..	..	77	79	103	105	110	*112*	140	..	185	158	242
Claughton	..	..	..	..	..	..	119	142	142	167	184	177	..
Giggleswick	37	67	91	96	112	120	127	141	145	156	160	166	245
Ambleside	30	81	..	97	..	..	122	..	..	..	..	..	296
Egremont	43	46	83	92	113	115	115	131	137	152	166	156	247
Cronkbourne	..	*121*	..	78	126	122	125	..	..	..	..	*224*	269
Orry's Dale	70	92	96	98	..	110	113	132	135	..	163	153	242
G.													
Edgeworthstown ..	58	..	79	87	..	116	122	..	140	..	..	..	..
Loughbrickland ..	66	69	89	91	..	111	121	139	140	..	..	..	264
Saintfield	..	..	78	90	..	116	125	142	146	190	..	180	247
Antrim	46	68	..	89	..	116	..	136	137	181	..	194	255
Londonderry	54	75	84	103	..	118	123	141	149	200	..	206	..
Ballynagard	33	72	..	..	..	108	..	..	..	..	..	178	..
H.													
Dalshangan	49	82	..	101	..	..	..	..	..	..	..	..	..
Tynron	65	84	94	100	..	130	134	151	147	201	182	..	..
Thornhill	39	79	106	96	125	..	125	141	138	..	..	..	..
Jardington	38	69	86	103	..	..	125	138	..	183	176	..	..
Helensburgh.....	41	74	98	97	113	117	126	144	146	198	..	162	231

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TABLE II.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1893—*Continued.*

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse Chestnut.	Hawthorn.	White Ox-eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bind-weed.	Ivy.
I.													
Doddington	63	64	79	91	109	114	116	138	145	..	..	..	..
Driffield	39	46	..	96	..	133	132	..	155	184	..	187	262
Thirsk	38	47	67	85	108	114	110	140	142	173	184	180	268
East Layton	67	66	97	100	120	124	132	148	159	199	193	..	261
Durham	48	61	83	100	..	131	129	146	147	..	165	..	*314*
Low Fell	71	84	90	..	..	142	130	..	159	196	197	205	268
Cambois	..	52	84	93	*147*	..	132	153	160	..	182	191	..
J.													
Aberdeen	..	74	114	..	..	135	132	160	161	..	196	..	..
K.													
Inverbroom	51	58	102	103	..	114	110	..	141	..	..		..

The dates in italics have not been taken into consideration when calculating the means given in Table III. (pp. 138-9).

Explanation of the dates in the Tables.

1– 31	are in January.	182–212	are in July.
32– 59	„ February.	213–243	„ August.
60– 90	„ March.	244–273	„ September.
91–120	„ April.	274–304	„ October.
121–151	„ May.	305–334	„ November.
152–181	„ June.	335–365	„ December.

and North-east, and also throughout Scotland and Ireland. The crop of hay was however the worst of the year. (See Table IV.). Sir John Lawes directed attention at the time to three noteworthy features in the English corn-crops, viz. 1. The poor yield; 2. The good quality of the grain; and 3. The shortness of the straw.

The Year 1893.

In complete contrast to the phenological year of 1892, this proved a singularly forward one throughout the Kingdom. The February and March plants were certainly as a rule later than usual in coming into blossom, and more especially was this the case in all the colder parts of our Islands, but after this the dates were everywhere more or less in advance of the average, and during the height of the flowering season the departures from the mean were often considerable.

The year 1893 was one of the worst agricultural years ever known throughout fully two-thirds of England, whereas in Scotland the crops all round, with the exception of hay, have seldom been more abundant. The one redeeming feature of this generally disastrous year was the autumn, which proved everywhere exceptionally favourable to the farmer. Moreover, it would be difficult to estimate at its true value the benefits the land must have received through the disintegrating effect of the frost of last winter, followed as it was by the fertilising influence of nine months of almost uninterrupted sunshine.

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Observers' Notes.

DECEMBER, 1892.—*Tiverton* (A.). We have roses and Christmas roses open at the same time. *Wicklow* (B.). 26th. All tropæolums killed by frost. *Pennington* (C.). Redwings, fieldfares, green and golden plover numerous by the end of the month. 23rd. Picked a bunch of primroses in a copse. *Burbage* (D.). 25th. Wallflowers in bloom until cut by last night's frost. *Inverbroom* (K.). 1st. Noticed a very large flock of snow bunting at sea-level, a very rare occurrence on the west coast. 5th. Shot three grouse in the valley not 100 ft. above sea-level, where grouse had never been seen before.

JANUARY, 1893. *Aberystwith.* (A.). 6th and 7th. Great rush of migrants down the coast, caused by the first decided snowfall of the winter. Many thousands of starlings and skylarks passed. 8th. Picked up several starved and crippled larks. *Pennington* (C.). 20th. Winter aconite in flower. *Strathfield Turgiss* (C.). 22nd. Winter aconite in flower. *Churt* (C.). 23rd. Winter aconite in flower. *Addlestone* (C.). 31st. Winter aconite in flower. *Whatley* (C.). 23rd. Winter aconite in flower. *Cheltenham* (D.). The severe frost tried vegetation very much, and all the cabbage tribe suffered severely. *Beckford* (D.). There being no snow on the ground, vegetation suffered much during the long frost—all the celery frosted, and spring cabbage killed. *Berkhamsted* (D.). Owing to the great depth to which the frost penetrated the ground, all my montbretias and globe artichokes were killed. The latter had passed through the previous eight winters without serious injury. 24th. Winter aconite in flower. *Ross* (D.). Frost destructive to many half hardy plants owing to the suddenness with which it set in. *Churchstoke* (D.). Swedes have stood the frost, but it destroyed the turnips. *Lexden* (E.). 25th. Winter aconite in flower. *Penmaenmawr* (F.). Fieldfares, redwings, and song thrushes suffering very much from severe frost and snow. *Edgworthstown* (G.). 22nd. Snowdrop in flower. *Tynron* (H.). Half the shoots on a Gloire de Dijon trained up the house wall were killed by frost. *Driffield* (I.). Turnips much damaged by frost. *Durham* (I.). Wild ducks have been very scarce. Lapwings left during the frost, but returned on 23rd. *Cambois* (I.). Turnip crop much injured by frost.

FEBRUARY.—*Aberystwith* (A.). 4th. Frog spawn seen. *Blandford* (C.). 10th. The first adder seen here. They are very common this year. My keeper, without moving, shot seven basking in some underwood, besides several curled up together. Frog spawn seen. *Pennington* (C.). No spring corn put in, owing to constant wet weather. 11th. Frog spawn seen. *Croydon* (C.). 10th. Winter aconite in flower. *Whatley* (C.). 2nd. Primroses in flower. *Harrogate* (D.). 19th. First frog spawn. *Dalshangan* (H.). 4th. Winter aconite in flower.

MARCH.—*Marazion* (A.). 23rd. Sand martins and wheatears first seen. *Mawnan Smith* (A.). 21st. Chiff-chaff seen. *Bassaleg* (A.). 26th. Sycamore in full leaf. *Wicklow* (B.). 16th. Foliage of trees, &c., extraordinarily heavy and good. Crops so far promise well. *Bembridge* (C.). 4th. Gathered mushrooms in two different places. 5th. Elms in bloom. 30th. Humming bird-moth seen. *Pennington* (C.). A splendid March for working the land. 17th. First blackbird's egg. *Swanley* (C.). 31st. Cherry in flower. *Bickley* (C.). 12th. Painted-lady butterfly seen. *Churt* (C.). Damage done by frost to my tea roses exceptionally great. 19th. Gloire de Dijon rose in flower on a south-east wall. *Addlestone* (C.). 15th. Almond in flower. *Whatley* (C). 25th. Insects abundant, especially butterflies and beetles. *Cheltenham* (D.). 12th. Almond in blossom. *Watford* (D.). Cherry trees in full blossom. *St. Albans* (*Newberries*) (D.). 20th. Frog spawn seen. *Churchstoke* (D.). 18th. Frog spawn seen. *Thurcaston* (D.). The severe frosts of this month did much damage to blossoms. Laburnums in some places had but one flower on a raceme, and the horse-chestnuts lost large quantities of flowering shoots. *Belton* (D.). 12th. Wryneck heard and seen. *Helensburgh* (H.). 21st. Hedges quite green. *Thirsk* (I.). 29th. Butterflies unusually abundant for the time of year.

APRIL.—*Marazion* (A.). 11th. Clouded-yellow and brimstone butterflies seen. *Mawnan Smith* (A.). 24th. Gooseberries ¼ to ¾ in. long. *Clifton* (A.). 19th. Swarm of bees taken. *St. Arvan's* (A.). 10th. White butterflies numerous. *Aberystwith* (A.). Lilacs and all fruit trees in full bloom by end of

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TABLE III.—MEAN DATES (DAY OF YEAR) FOR THE FIRST FLOWERING OF PLANTS IN 1893, AND THEIR VARIATIONS FROM THE AVERAGE.

Plants.	A. Eng. S.W.			B. Ireland, S.			C. Eng. S.			D. Eng. Mid.		
	1893.	Approximate Average.	Variation from Average.	1893.	Approximate Average.	Variation from Average.	1893.	Approximate Average.	Variation from Average.	1893.	Approximate Average.	Variation from Average.
Hazel	33	23	+10	34	21	+13	38	31	+ 7	39	35	+ 4
Coltsfoot	53	44	+ 9	39	42	− 3	60	52	+ 8	62	56	+ 6
Wood Anemone	79	58	+21	65	56	+ 9	75	66	+ 9	79	70	+ 9
Blackthorn	80	91	−11	59	91	−32	86	91	− 5	89	93	− 4
Garlic Hedge Mustard	95	111	−16	94	111	−17	104	111	− 7	101	113	−12
Horse Chestnut	101	126	−25	101	126	−25	111	126	−15	112	128	−16
Hawthorn	109	131	−22	102	131	−29	112	131	−19	113	133	−20
White Ox Eye	125	139	−14	126	139	−13	126	139	−13	132	141	− 9
Dog Rose	130	156	−26	128	160	−32	136	155	−19	138	158	−20
Black Knapweed	151	175	−24	130	179	−49	151	174	−23	158	177	−19
Harebell	176	189	−13	..	*193*	..	168	188	−20	184	191	− 7
Greater Bindweed	160	195	−35	161	199	−38	167	194	−27	169	197	−28
Ivy	245	263	−18	229	266	−37	257	270	−13	255	274	−19
Mean for the 13 Plants	118	131	−13	106	127	−21	122	133	−11	125	136	−11

Plants.	E. Eng. E.			F. Eng. N.W.			G. Ireland, N.			H. Scotland, W.		
	1893.	Approximate Average.	Variation from Average.	1893.	Approximate Average.	Variation from Average.	1893.	Approximate Average.	Variation from Average.	1893.	Approximate Average.	Variation from Average.
Hazel	38	36	+ 2	45	32	+13	51	29	+22	46	33	+13
Coltsfoot	56	57	− 1	66	53	+13	71	50	+21	78	54	+24
Wood Anemone	76	71	+ 5	87	67	+20	83	64	+19	96	68	+28
Blackthorn	85	95	−10	91	97	− 6	92	97	− 5	99	99	Av.
Garlic Hedge Mustard	101	115	−14	114	117	− 3	..	*117*	..	119	119	Av.
Horse Chestnut	109	130	−21	114	132	−18	114	132	−18	124	134	−10
Hawthorn	112	135	−23	119	137	−18	123	137	−14	128	139	−11
White Ox Eye	130	143	−13	136	145	− 9	140	145	− 5	144	147	− 3
Dog Rose	135	157	−22	140	161	−21	142	164	−22	144	164	-20
Black Knapweed	149	176	−27	158	180	−22	190	183	+ 7	194	183	+11
Harebell	187	190	− 3	172	194	−22	..	*197*	..	179	197	−18
Greater Bindweed	169	196	−27	162	200	−38	190	203	−13	162	203	−41
Ivy	246	273	−27	257	271	−14	255	271	−16	231	273	−42
Mean for the 13 Plants	123	136	−13	128	137	− 9	132	134	− 2	134	139	− 5

\+ indicates the number of days later than the average date.
— „ „ „ earlier „ „
Av. „ average date.

N.B.—The dates in italics have not been taken into consideration when calculating the mean dates at the bottom of the Table, nor the means for the British Isles.

first week. *Bembridge* (C.). 9th. Cuckoos and swallows numerous. 20th. Clouded yellow butterfly seen. *Buckhorn Weston*. (C.). 26th. Horse-chestnuts and hawthorns in full flower. *Pennington* (C.). Vegetables getting very scarce. Plants coming quickly into bloom, but flowers soon over. Pasture grass burnt up and feed very scarce—mangolds having to be drawn to the cattle

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TABLE III.—MEAN DATES (DAY OF YEAR) FOR THE FIRST FLOWERING OF PLANTS IN 1893, AND THEIR VARIATIONS FROM THE AVERAGE—*Continued.*

Plants.	I. Eng. N.E.			J. Scotland, E.			K. Scotland, N.			British Isles.		
	1893.	Approximate Average.	Variation from Average.	1893.	Approximate Average.	Variation from Average.	1893.	Approximate Average.	Variation from Average.	1893.	Approximate Average.	Variation from Average.
Hazel	54	37	+17	..	*88*	..	51	37	+14	43	31	+12
Coltsfoot	60	58	+ 2	74	59	+15	58	58	Av.	62	53	+ 9
Wood Anemone	83	72	+11	114	73	+41	102	72	+30	85	67	+18
Blackthorn	94	102	— 8	..	*103*	..	103	110	— 7	88	97	— 9
Garlic Hedge Mustard	112	122	—10	..	*123*	..	..	*130*	..	105	115	—10
Horse Chestnut	126	137	—11	135	138	— 3	114	145	—31	115	132	—17
Hawthorn	126	142	—16	132	143	—11	110	150	—40	117	137	—20
White Ox Eye	145	150	— 5	160	151	+ 9	..	*158*	..	136	144	— 8
Dog Rose	152	163	—11	161	166	— 5	141	173	—32	141	162	—21
Black Knapweed	188	182	+ 6	..	*185*	..	..	*192*	..	163	179	—16
Harebell	184	196	—12	196	199	— 3	..	*206*	..	181	193	—12
Greater Bindweed	191	202	—11	..	*205*	..	..	*212*	..	170	199	—29
Ivy	265	274	— 9	..	*277*	..	..	*276*	..	249	271	— 22
Mean for the 13 Plants	137	141	— 4	139	133	+ 6	97	106	— 9	127	137	—10

\+ indicates the number of days later than the average date.
— „ „ „ earlier „ „
Av. „ average date.

N.B.—The dates in italics have not been taken into consideration when calculating the mean dates at the bottom of the Table, nor the means for the British Isles.

daily. The medlar flowered 35 days earlier than in 1892. *Strathfield Turgiss* (C.). The wet February and dry warm March have produced early movements on the part of the birds, but vegetation generally is backward. *Swanley* (C.). 29th. Commenced picking gooseberries for market. *Chislehurst* (C.). Poisonous adder killed over 2 ft. long, none of the sort seen for 20 years. *Bickley* (C.). 20th. White water-lily in flower. *Coneyhurst* (C.). 30th. An oak in leaf and quite green. *Churt* (C.). 2nd. Wryneck first heard—an unusually early date. *Addlestone* (C.). At the end of the month hedge sides and fields were covered with flowers, and the trees with leaves. *East Molesey* (C.). 30th. The horse-chestnut avenue in Bushey Park now in full bloom—a remarkably early date. *Salisbury* (C.). A garden crab watched for 17 consecutive years flowered on the 4th, or three days later than in 1882. In 1879 it did not open a flower till May 22nd. *Whitchurch* (C.). 21st. Elms so fully out as to make complete shade. *Reading* (C.). 23rd. The river (Thames) is gradually falling, and is now 2 ft. below the usual level at this time of year. *Oxford* (D.). Hawthorn in flower on 20th, 18 days earlier than the previous earliest date, 1882. *Beckford* (D.). 14th. The blossom on the cherries, plums, and pears, damaged by frost. *St. Albans* (*Addiscombe Lodge*) (D.). Seeds, in spite of being watered, refused to germinate till rain came. Sweet peas sown March 20th came up April 18th. *Watford* (D.). 8th. Wryneck first seen and heard. *Berkhamsted* (D.). 1st. A wild cherry in flower a month in advance of the previous 7 years' average. *Ross* (D.). 3rd. 41 different wild plants noted in one week. *Breinton* (D.). 14th. Oaks and elms came into leaf together. *Burbage* (D.). Cuckoos unusually numerous this year. *Walsall* (D.). 17th. Orchards in full blossom. Have never known such a display of bloom in this district. *Beeston* (D.). The swallow was first seen two days later, and the cuckoo heard five days earlier than their respective average dates for the previous 18 years. 14th. Apples, cherries, and damsons in full bloom. *Hodsock* (D.). 1st. Wild cherry in flower. 24th. Elms in leaf and some oaks, but no beeches. *Harrogate* (D.). Apples, pears, and cherries generally in bloom. *Hitchin* (E.). Swift first seen.

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TABLE IV.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1893.

Station.	Song.	Migration.					Insects.				
	Song Thrush First heard.	Swallow First seen.	Cuckoo First heard.	Nightingale First heard.	Flycatcher First seen.	Swallow Last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
A.											
Marazion	33	103	107	..	..	279	79	82	85	123	154
Mawnan Smith	..	109	110	..	*81*	..	..	..	79	123	158
Falmouth	..	..	..	..	..	..	..	104	80	127	..
Liskeard	20	101	108	..	127	266	64	90	81	124	136
Tiverton	..	..	..	..	..	291	..	..	..	..	..
Westward Ho	24	87	103	..	..	..	..	..	71	99	152
Instow	..	107	113	..	..	..	59	85	86	97	146
West Bagborough	..	106	100	..	..	..	..	91	89	100	..
Sidcot	..	80	103	113	125	..	83	88	103	63	116
Clifton	..	..	93	113	..	..	..	81	88	93	142
Long Ashton	..	98	93	..	144	..	18	..	..	105	..
Penarth	..	..	..	..	..	..	72	78	80	106	146
Cardiff	35	96	109	..	141	283	50	88	..	..	..
Castleton	34	87	107	112	142	288	50	85	86	95	123
Bassaleg	31	106	107	112	..	291	38	60	..	..	..
St. Arvan's	28	105	107	110	134	282	22	45	81	100	160
St. David's	..	77	110	..	..	..	73	..	99	125	..
Aberystwith	25	94	109	..	129	271	..	..	87	109	154
B.											
Killarney	18	95	116	..	..	..	68	79	89	101	..
Wicklow	*107*	77	110	..	..	..	65	97	84	92	124
C.											
Bembridge	..	87	90	103	..	302	78	89	78	144	110
Blandford	..	99	103	100	130	277	61	84	91	92	145
Buckhorn Weston	13	99	101	..	..	..	25	99	..	91	128
Pennington	28	101	100	108	137	293	35	79	88	111	155
Strathfield Turgiss	49	93	100	103	115	275	79	93	92	108	135
Bexhill-on-Sea	28	101	103	101	122	*324*	88	94	88	123	144
Muntham	30	94	101	105	142	..	63	91	94	109	..
Dover	..	..	..	..	..	301	..	..	..	..	..
Bidborough	..	..	104	..	..	..	66	..	90	..	..
Lynsted	..	111	110	111	..	..	..	..	..	..	..
Swanley	..	..	108	..	..	..	..	..	88	141	..
Chislehurst	..	109	104	104	..	282	..	..	88	112	..
Bickley	..	106	108	106	130	..	50	81	83	115	..
Coneyhurst	36	102	99	104	130	278	50	81	93	..	..
Churt Vicarage	31	100	107	114	..	284	50	95	87	109	*170*
Churt	41	85	104	106	126	..	50	56	93	96	..
Cranleigh	..	..	100	94	..	288	..	..	..	..	..
Winterfold	49	96	100	102	118	285	50	55	..	..	..
Willinghurst	35	..	100	106	..	269	..	88	94	..	..
Oxshott	31	109	106	113		286	..	63	..	..	..
Ashtead	..	105	105	104	..	..	50	..	85	99	133
Addlestone	30	96	93	101	99	277	50	50	84	..	..
Croydon	37	.	..	..	..	..	50	102	92	..	..
East Molesey	24	103	110	108	..		51	84	104	125	..
Farley	..	..	102	106	..		..		..	..	..
Salisbury	..	110	..	..	..	291	..	..	80	..	..
Marlborough	35	98	109	109	128	..	..	..	82	113	..
Whatley	24	100	108	109	*154*	281	50	84	84	107	161
Whitchurch	23	..	111	110	..	..	84	..	..	..	..
Reading	91	..	91	*122*		..	..	73	..	121	..
D.											
Oxford	..	93	107	.	..	..	..	..	86	..	140
Cheltenham	29	105	105	114	128	283	50	80	83	99	125

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TABLE IV.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1893—*Continued.*

Station.	Song.	Migration.					Insects.				
	Song Thrush First heard.	Swallow First seen.	Cuckoo First heard.	Nightingale First heard.	Flycatcher First seen.	Swallow Last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
D.											
Beckford	22	102	105	104	136	275	22	94	98	108	129
Watford	24	105	104	106	*160*	..	62	..	79	107	..
Broxbourne	..	..	108	108	..	..	..	108	91	..	..
St. Albans (The Grange)	..	..	..	..	..	..	50	..	84	..	..
St. Albans (Add. Lodge)	..	122	113	111	..	..	..	96	84	106	..
St. Albans (St. Peter's Street)	29	98	99	106	148	283	..	..	..	..	..
St. Albans (Newberries)	..	98	104	108	127	..	68	82	92	..	..
Berkhamsted	29	105	100	109	131	..	50	75	80	103	..
Harpenden	..	108	97	108	..	..	..	119	89	112	128
Ross	25	109	109	..	136	..	39	79	83	..	..
Breinton	40	104	109	..	145	280	51	59	50	94	*181*
Evesham	50	90	107	103	..	282	61	64	82	118	161
Henley-in-Arden	..	106	92	109	124	..	63	67	..	109	..
Northampton	..	99	92	107	134	..	50	..	87	..	..
Churchstoke	45	..	102	..	..	..	50	88	89	93	..
Burbage	18	106	106	109	138	281	50	93	63	126	..
Thurcaston	..	102	..	..	..	..	..	111	97	108	..
Uppingham	..	105	108	112	..	..	70	59	..	108	..
Walsall	44	111	113	..	..	275	50	94	93	..	..
Tean	25	108	106	..	..	281	50	..	95	112	..
Beeston	22	109	113	..	..	..	50	68	78	123	..
Hodsock	30	101	110	111	131	282	24	97	108	111	..
Eaton	..	109	110	107	122	..	50	..	..	..	..
Bakewell	..	94	117	..	..	..	66	..	95	..	..
Macclesfield	45	113	115	..	..	273	..	80	96	144	..
Belton	20	105	108	106	131	285	46	94	81	112	159
Harrogate	29	104	95	..	120	294	67	88	..	..	..
E.											
Hertford	..	..	..	..	..	292	..	..	..	..	..
Hitchin	32	98	109	94	..	..	31	94	93	112	..
Ashwell	..	100	107	106	136	285	50	..	..	..	..
Bocking	..	..	109	113	..	..	..	..	..	..	..
Lexden	26	109	109	109	140	280	49	95	87	111	148
Sproughton	30	112	111	105	133	287	50	88	83	108	124
Tacolneston	30	..	..	..	..	..	25	..	..	..	..
Wryde	..	110	115	..	118	..	67	..	115	..	123
F.											
Heswall	28	97	103	..	125	..	58	61	..	121	..
Penmaenmawr	..	106	107	..	114	..	79	81	85	96	163
Claughton	..	112	115	..	..	..	..	..	..	..	..
Giggleswick	27	105	115	..	138	279	50	..	105	..	..
Ambleside	33	107	116	..	118	..	93	117	.	113	..
Egremont	27	101	109	..	127	277	41	85	92	117	169
Cronkbourne	29	*135*	123	..	..	299	25	87	117	118	134
Orry's Dale	25	*124*	112	..	..	..	34	95	..	..	..
Sulby	*79*	110	121	..	..	253	58	89	125	..	140
G.											
Edgeworthstown	22	95	112	..	124	292	90	81	88	..	..
Loughbrickland	31	96	110	..	..	273	60	32	109	110	..
Saintfield	..	102	114	..	..	..	67	113	100	113	170
Antrim	35	111	117	..	127	275	50	96	100	113	..
Londonderry	33	109	112	..	..	..	..	99	112	114	172
Ballynagard	22	95	112	..	..	280	..	83	..	112	168
H.											
Dalshangan	31	110	114	..	..	259	51	97	112	..	..

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TABLE V.—DATES (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1893—*Continued*.

Station.	Song.	Migration.					Insects.				
	Song Thrush First heard.	Swallow First seen.	Cuckoo First heard.	Nightingale First heard.	Flycatcher First seen.	Swallow Last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
H.											
Tynron	49	100	112	..	..	..	79	93	112	..	..
Thornhill	..	113	113	..	..	..	67	80	..	..	..
Jardington	36	113	115	..	139	..	..	97	109	..	166
Helensburgh	23	105	114	..	..	..	82	96	97	..	..
I.											
Doddington	..	..	109	..	..	..	..	..	..	..	..
Driffield	46	109	114	..	..	297	..	64	94	..	..
Thirsk	29	102	115	..	..	293	29	64	76	115	..
East Layton	37	114	105	..	136	274	49	71	100	129	168
Durham	30	112	121	..	..	290	91	51	109	..	..
Low Fell	33	118	109	..	..	273	..	112	..	..	..
Cambois	47	112	115	..	..	263	..	..	112	..	..
J.											
Aberdeen	28	119	121	..	130	272	81	131	128	..	..
K.											
Inverbroom	..	111	122	..	..	..	60	65	102	110	..
Mean Dates for the British Isles in 1893	31 Jan.	103 April 13th	107 April 17th	107 April 17th	130 May 10th	282 Oct. 9th	56 Feb. 25th	84 March 25th	91 April 1st	110 April 20th	145 May 25th
Mean Dates for 1891–2	Feb. 4th	*April 19th*	*April 25th*	*April 25th*	*May 10th*	*Oct. 15th*	*Feb. 27th*	*April 12th*	*April 16th.*	*May 13th*	*June 15th*

The dates in italics have not been taken into consideration when calculating the means for the British Isles.

Penmaenmawr (F.). 6th. Cuckoos very plentiful. *Giggleswick* (F.). I have never before seen such blossom on the sycamore and ash. *Saintfield* (G.). 8th. Never remember to have seen the hedges so green so early in the year. *Inverbroom* (K.). 29th. Lilac in flower.

MAY.—*Marazion* (A.). The drought has had a disastrous effect on the staple produce of this district, potatoes and broccoli. One grower planted one ton of potatoes in a meadow, and the produce weighed exactly one ton and nine pounds. *Mawnan Smith* (A.). Fruit blossom abundant. 18th. Swift seen. 31st. Hay being cut, very poor crop. Cows turned into uncut hay. *Falmouth* (A.). 14th. Ripe wild strawberries gathered. *Liskeard* (A.). Trees and shrubs flowering very freely. Owing to drought and sunshine everything brought very rapidly to maturity. Scarcely any hay. *Sidcot* (A.). Many wild plants appear in a very stunted form, especially the orchis, many being in full flower and less than an inch high. *Clifton* (A.). Blackthorns, hawthorns, and chestnuts were thickly covered with blossom, but owing to the great heat the flowers quickly faded. The emergence of insects was remarkably early. *Long Ashton* (A.). The grass has been entirely burnt up, and for some few days smelt just like hay. *Penarth* (A.). The warm weather caused insects to appear in great numbers during the spring. The different species of lepidoptera were about a month earlier than usual. *Castleton* (A.). All grass lands suffered and remained bare for lack of moisture. The nightingale, which only visits these parts in exceptionally fine seasons, was in full song. *Bassaleg* (A.). 30th. Wheat in full ear. *St. Arvan's* (A.). Pasture lands very bare and brown. *St. David's* (A.).

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TABLE V.—Estimated Yield of Farm Crops in 1893.

Description of Crop.	England.						Scotland.			Ireland.	British Isles.
	A. SW.	C. S.	D. Mid.	E. E.	F. NW.	I. NE.	H. W.	J. E.	K. N.	B. and G. S and N.	
Wheat	2% O. Av.	21% U. Av.	4% U. Av.	17% U. Av.	15% O. Av.	7% O. Av.	14% O. Av.	3% O. Av.	39% O. Av.	Av.	U. Av.
Barley	14% U. Av.	35% U. Av.	14% U. Av.	28% U. Av.	7% O. Av.	3% O. Av.	8% O. Av.	6% O. Av.	12% O. Av.	Av.	U. Av.
Oats	11% U. Av.	36% U. Av.	13% U. Av.	31% U. Av.	Av.	Av.	9% O. Av.	9% O. Av.	Av.	Av.	U. Av.
Corn Harvest began, average Date	201 (July 20)	201 (July 20)	208 (July 27)	208 (July 27)	212 (July 31)	218 (Aug. 6)	221 (Aug. 9)	227 (Aug. 15)	233 (Aug. 21)	213 (Aug. 1)	214 (Aug. 2)
Beans	U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	U. Av.	U. Av.	O. Av.	U. Av.	..	Av.	U. Av.
Peas	U. Av.	Much U. Av.	U. Av.	U. Av.	U. Av.	Av.	..	Av.	..	O. Av.	U. Av.
Potatoes	O. Av.	U. Av.	Av.	U. Av.	U. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.
Turnips	U. Av.	U. Av.	U. Av.	U. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	Av.
Mangolds	U. Av.	Much U. Av.	U. Av.	Much U. Av.	O. Av.	U. Av.	O. Av.	..	..	O. Av.	U. Av.
Hay (Permanent Pastures)	48% U. A.	71% U. A.	62% U. A.	62% U. A.	35% U. A.	35% U. A.	2% U. A.	7% U. A.	47% U. A.	U. A.	Much U. A.
Hay (Clover, &c.)	33% U.A.	55% U.A.	46% U. A.	51% U. A.	37% U. A.	26% U. A.	3% O. A.	11% U. A.	37% U. A.	U. A.	Much U. A.

The variations from the average relating to Wheat, Barley, Oats and Hay have been obtained from the *Agricultural Produce Statistics* issued by the Board of Agriculture, but those for the other crops from Returns which appeared in the *Agricultural Gazette*.

TABLE VI.—Estimated Yield of Fruit Crops in 1893.

Description of Crop.	England.						Scotland.	Ireland.	British Isles.
	A. SW.	C. S.	D. Mid.	E. E.	F. NW.	I. NE.	H. J. and K. W. E. and N.	B. and G. S. & N.	
Apples	O. Av.	Av.	Av.	Av.	Av.	Av.	Av.	O. Av.	Av.
Pears	Av.	U. Av.	U. Av.	Av.	U. Av.	U. Av.	U. Av.	Av.	U. Av.
Plums	O. Av.	Av.	O. Av.	O. Av.	Av.	O. Av.	Av.	Av.	Av.
Raspberries	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.
Currants	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.
Gooseberries	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.
Strawberries	Av.	U. Av.	U. Av.	U. Av.	Av.	U. Av.	Av.	U. Av.	U. Av.

Symbols:—O. = Over. U. = Under. Av. = Average. This Table has been compiled from Returns which appeared in the *Gardeners' Chronicle*.

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TABLE VII.

APPROXIMATE VARIATIONS FROM THE AVERAGE IN MEAN TEMPERATURE, RAINFALL, AND SUNSHINE, 1892–93.

Winter 1892–93.

Temperature.

Months.	Eng. SW.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. NW.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
December	—2·0	+0·3	—2·0	—3·0	—2·8	—2·5	—0·3	—2·0	—2·5	—3·0	—2·3
January	—3·8	—2·3	—5·0	—2·8	—4·5	—2·8	+1·5	—2·3	—2·5	—1·5	—3·0
February	+1·8	+1·0	+2·5	+2·0	+1·5	+1·8	+1·0	+1·3	+1·3	+1·0	+1·0
Winter ...	—1·3	—0·3	—1·5	—1·3	—1·9	—1·2	+0·7	—1·0	—1·2	—1·2	—1·4

Rain.

	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
December	—2·3	—1·6	—1·6	—1·6	—1·3	—1·3	—1·0	—2·6	—1·4	—1·6	—1·9
January	—1·5	—0·8	—0·8	—0·7	0·0	—1·8	—1·0	—3·4	—0·6	—0·9	—1·0
February	+2·0	+1·3	+1·0	+0·9	+0·8	+1·2	+1·0	+1·1	+0·4	+0·4	+0·5
Winter	—1·8	—1·1	—1·4	—1·4	—0·5	—1·9	—1·0	—4·9	—1·6	—2·1	—2·4

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
December	+14	— 4	+19	+18	+13	+20	— 5	— 4	+19	+ 4	—11
January	+11	—15	— 8	0	— 8	— 5	+ 8	+10	— 1	—19	+ 5
February	— 6	— 4	+ 6	— 2	— 6	—12	—16	— 5	+ 3	— 6	— 4
Winter	+19	—23	+17	+16	—11	+ 3	—13	+ 1	+21	—21	—10

Spring 1893.

Temperature.

	°	°	°	°	°	°	°	°	°	°	°
March	+3·2	+2·6	+3·0	+3·2	+3·0	+2·8	+2·6	+2·0	+3·0	+2·2	+1·8
April	+5·8	+4·5	+4·5	+4·5	+3·0	+4·8	+4·3	+3·8	+1·8	+3·3	+3·3
May	+4·2	+4·0	+3·4	+3·6	+2·8	+3·6	+4·0	+3·4	+3·0	+3·2	+2·8
Spring	+4·4	+3·7	+3·6	+3·8	+2·9	+3·7	+3·6	+3·1	+2·6	+2·9	+2·6

Rain.

	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
March	—2·1	—2·4	—1·0	—1·4	—1·0	—0·9	—1·1	—1·7	—0·7	—1·4	—0·5
April	—2·1	—1·5	—1·6	—1·4	—1·5	—1·4	—1·0	—1·1	—1·4	—0·9	—0·7
May	—1·1	—0·8	—1·3	—0·7	—1·2	—0·5	—0·8	—0·7	—0·5	—1·0	—0·9
Spring	—5·3	—4·7	—3·9	—3·5	—3·7	—2·8	—2·9	—3·5	—2·6	—3·3	—2·1

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
March	+ 70	+ 26	+ 91	+ 86	+84	+ 55	+17	+39	+ 65	+50	— 9
April	+ 98	+ 37	+115	+105	+95	+ 81	+30	+63	+ 90	+22	+ 8
May	+ 40	+ 40	+ 36	+ 24	+18	— 19	—63	—19	— 3	—34	—56
Spring	+208	+103	+242	+215	+197	+117	—16	+83	+152	+38	—57

\+ indicates above the average, — below it.

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TABLE VII.

VARIATIONS FROM THE AVERAGE—*Continued.*

Summer 1893.

Temperature.

Months.	Eng. SW.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. NW.	Ire. N.	Scot. W.	Eng. NE.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
June	+3·3	+3·0	+2·8	+3·0	+1·8	+3·3	+3·5	+2·8	+1·8	+2·3	+2·5
July	+1·8	+1·5	+1·0	+1·3	+0·8	+1·8	+1·5	+1·0	−0·5	+0·3	+1·8
August	+3·0	+3·2	+2·8	+3·8	+2·6	+3·4	+3·0	+2·6	+3·4	+2·8	+2·4
Summer ..	+2·7	+2·6	+2·2	+2·7	+1·7	+2·8	+2·7	+2·1	+1·6	+1·8	+2·2

Rain.

	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
June	−1·1	−0·8	−0·9	−1·1	−0·9	−0·4	−0·6	−1·5	−0·6	+0·6	−1·6
July	+1·8	−0·4	+1·2	+0·3	+0·2	+0·2	+0·5	+0·2	+0·4	−0·3	+0·4
August	−1·4	+0·3	−1·2	−1·0	−0·3	−0·6	+0·9	−0·6	−0·7	−0·4	+0·2
Summer ..	−0·7	−0·9	−0·9	−1·8	−1·0	−0·8	+0·8	−1·9	−0·9	−0·1	−1.0

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
June	+ 71	+16	+ 44	+36	+35	+36	+ 38	+36	+30	+ 1	+ 6
July	+ 1	− 6	+ 6	− 7	− 8	+ 1	+ 30	− 5	−12	−26	−27
August	+ 44	+41	+ 55	+58	+40	+39	+ 41	+44	+52	+23	−17
Summer ..	+116	+51	+105	+87	+67	+76	+109	+75	+70	− 2	−38

Autumn 1893.

Temperature.

	°	°	°	°	°	°	°	°	°	°	°
September ..	+0·3	−0·3	0·0	+0·3	−1·3	+0·3	+0·3	−0·5	0·0	−0·8	−1·0
October	+1·3	0·0	+2·5	+2·5	+2·5	+2·0	+0·8	+1·3	+1·8	+1·8	+1·3
November	−2·2	−3·0	−2·2	−2·0	−1·4	−1·6	−1·6	−1·8	−1·0	−2·6	−3·2
Autumn ..	−0·2	−1·1	+0·1	+0·3	−0·1	+0·2	−0·2	−0·3	+0·3	−0·5	−1·0

Rain.

	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
September ..	−1·1	−1·0	−0·2	−1·5	−1·6	+0·6	−0·1	−1·0	−0·8	−0·6	+3·4
October	+0·6	−0·4	+1·1	−0·5	+0·2	+0·3	+0·3	+1·3	−1·2	−0·4	+3·0
November ...	−2·2	−2·0	−1·2	−1·5	+0·2	−1·4	−1·6	−2·4	−0·2	−0·5	+2·4
Autumn ..	−2·7	−3·4	−0·3	−3·5	−1·2	−0·5	−1·4	−2·1	−2·2	−1·5	+8·8

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
September....	+13	+16	+17	+31	+19	+ 1	+23	+20	+34	+ 6	0
October	+ 3	+ 4	+21	+20	+26	+ 8	+ 4	+11	+43	+18	−36
November	+26	+13	+18	+12	+13	+13	+31	+32	+18	+ 3	−13
Autumn....	+42	+33	+56	+63	+58	+22	+58	+63	+95	+27	−49

The above Table has been compiled from the variations from the mean given in the *Weekly Weather Reports* issued by the Meteorological Office.

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Grass lands generally scorched and bare. Much late sown barley has not germinated, and turnips have come up and withered away. *Aberystwith* (A.). 31st. Grass crop extremely thin and scanty. *Killarney* (B.). No real injury done here by drought. 21st. Peas and potatoes ready for eating. *Bembridge* (C.). 8th. Gathered ripe strawberries. Meadow and grass crops dried up, no prospect of any hay. Wheat crops suffering. Barley not half sown, and what has

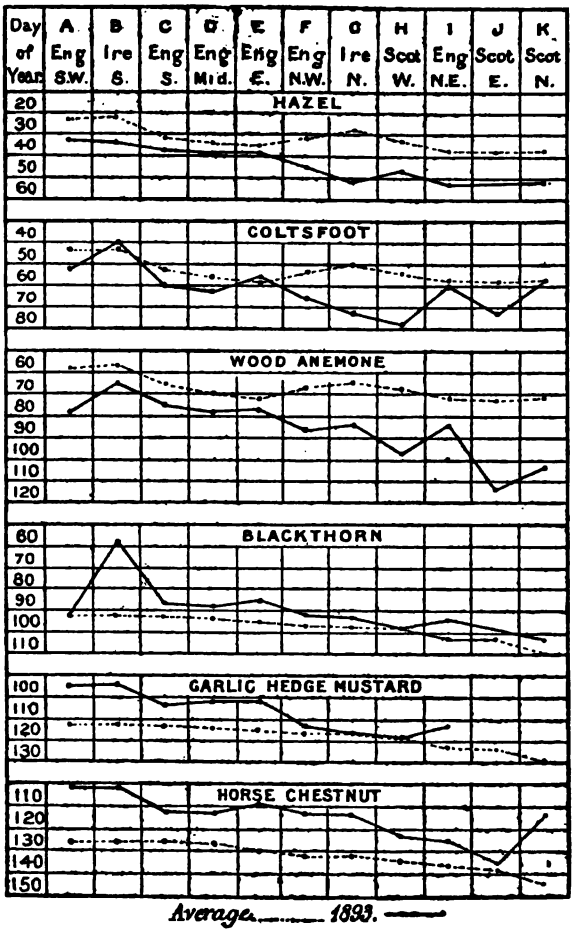

FIG. 1.—Mean Dates (Days of Year) of Flowering of the Plants in 1893, and also the Average Dates.

been sown remains dormant, as is the case with many other small seeds. *Buckhorn Weston* (C.). All flowering shrubs and trees have bloomed in an unusual degree, while other plants have not been up to the average. A great scarcity of birds this season. 10th. Picked ripe strawberries. 15th. No food in the pastures for the cattle. *Pennington* (C.). 5th. Gathered a bunch of Maréchal Niel and Gloire de Dijon roses from a wall. 22nd. Commenced cutting permanent pasture grass, the worst crop ever known. *Strathfield Turgiss* (C.). Plants flowering abnormally early, but their growth greatly stunted. Migratory birds do not seem to have been affected by the unusual weather, indeed, some are later than the average. From the dryness of the weather, the mud using birds, especially swallows, martins, and swifts, have had great difficulty in making

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their nests, several falling from the non-coherence of the material employed. The late building thrushes and nuthatches also have been sore put to for "clay." *Lynsted* (C.). Owing to a wet February and drought following, a large acreage of land intended for spring corn has not been sown. *Farnborough* (C.). 20th. Strawberries sent to market, most unusually early for field grown fruit. *Swanley* (C.). Seeds germinate very slowly. *Bickley* (C.). Foliage on trees full and

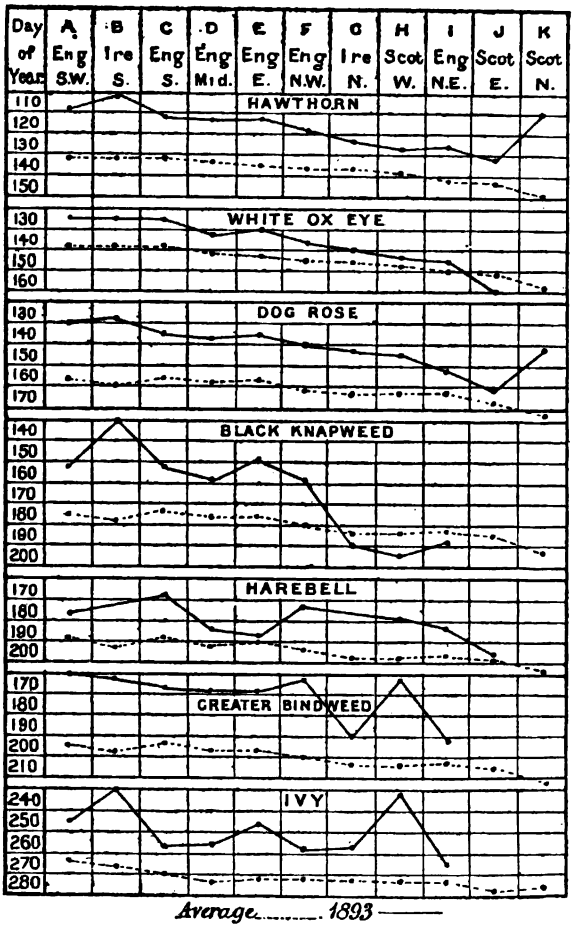

FIG. 2.—Mean Dates (Days of Year) of Flowering of the Plants in 1893, and also the Average Dates.

perfect, also flowers, especially horse-chestnuts. *Churt* (C.). 1st. May-fly seen. 30th. Dahlias damaged by frost, and in the lower portions of the parish the potato haulm was killed. 31st. The rise of the May-fly is now practically over. In many years it is hardly beginning at this date. *Oxshott* (C.). Hardly any grass or vegetables, owing to the absence of rain. Wheat ears fully formed by end of month. *Ashtead* (C.). Young seedling trees, especially beech, killed by drought. At end of month there were a number of bright red and brown shoots to be seen on the oak, maple, dogwood, &c., reminding one of the so-called "lammas shoots" usually seen in August. *Addlestone* (C.). Seeds sown did not germinate owing to dryness of soil. 30th and 31st. Potatoes blackened by frost. Grasses, corn, &c., flowering prematurely and very short in the stalk.

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East Molesey (C.). 15th. Trees and shrubs none the worse for the long drought, but small plants drooping and grass dried up. *Farley* (C.). Crops much injured by drought, particularly the grass. 7th. Gloire de Dijon and Maréchal Niel roses in bloom. Hawthorn in full beauty before May 1st. 31st. Potatoes injured by frost. *Marlborough* (C.). Common yellow toadflax (Linaria vulgaris) 44 days in advance of its average time, and the earliest yet observed. *Reading* (C.). The hay off three fair sized meadows was loaded on one cart. *Oxford* (D.). 15th. Dog rose in flower 15 days earlier than the previous earliest date, May 30th, 1880. *Cheltenham* (D.). Very fine show of blossom on fruit trees, but cold nights and drought prevented much of it setting. Flowers of cowslips, buttercups, ox-eye daisies, &c., stunted and small, but trees and shrubs, the roots of which go down deeper, blossomed splendidly. *Beckford* (D.). The foliage of the woods is magnificent, and there is a grand show of blossom on the fruit trees. Some of the field grasses not worth cutting. 20th. Strawberries ripe. 29th. Red currants ripe. *Watford* (D.) Few wild flowers to be met with. Many bullfinches in the garden, which is unusual for Watford. *Broxbourne* (D.). Never saw the blossom on the apple, pear, peach, plum trees, &c., finer or more abundant. *St. Albans* (D.). Foliage scanty, blossom abundant. *Berkhamsted* (D.). 10th. A wild dog rose in blossom, 31 days earlier than the average for the previous seven years. *Evesham* (D.). The first crop of peas almost a failure. One farmer got nothing but fodder for his cattle from 30 acres. Many fields sheets of white ox-eye, in exceptional abundance, but undersized. *Northampton* (D.). Pastures dried up. Plants flowered extremely early, but the blossom did not last long. Caterpillars were very destructive to foliage. *Burbage* (D.). Low growing vegetation has suffered severely from the drought, but the trees, with the exception of some caterpillar and aphis attacks, have thriven remarkably well. Grass keeps dreadfully short. Clover leys, strange to say, have wonderful crops with some plants 3 ft. high. 29th. First green gooseberries picked for market, 28 days earlier than in 1892. 30th and 31st. Runner beans and potatoes blackened by frost. *Thurcaston* (D.). First blossom out on hawthorn on April 19th, and out of flower on May 19th. *Walsall* (D.). 20th. No grass. Lawns scorched into brown and bare patches. *Tean* (D.). The grass has not suffered much from the drought here. Indeed, the farmers expect a specially good hay crop. *Beeston* (D.). 8th. Lawns burnt brown as in summer. *Hodsock* (D.). 8th. Gathered a dish of strawberries. *Bakewell* (D.). 31st. Vegetation has not suffered much from the recent drought. Outlook for crops fairly hopeful. *Macclesfield* (D.). Have not suffered much from drought here. Blight and caterpillars have almost stripped the apple trees of leaves. 1st. Most forest trees in full foliage. *Belton* (D.). Grass parched, and in places killed by drought. Strawberries ripe. *Hitchin* (E.). 2nd. Landrail heard. *Lexden* (E.). We are feeding blackbirds and thrushes the same as in a hard frost, as they could get nothing off the lawn. *Sproughton* (E.). Absolutely no grass, not even on the water meadows. *Wryde* (E.). 9th. Finished sowing barley. Very little came up at all until July, and never came to maturity, owing to dry weather. 25th. Ploughed up beans sown in February, they were not more than 6 ins. high. 31st. Pastures appear baked up, with grass dying. Some spring corn has remained in the ground nearly two months, and is as dry as when put in. *Penmaenmawr* (F.). 16th. Strawberries ripe. 28th. Hay a very short crop. *Ambleside* (F.). An early season with short spring growths—hay, trees, &c. *Orry's Dale* (F.). The lilac has flowered in unusual profusion. *Edgeworthstown* (G.). 31st. The rainfall has been very light, all crops, however, are in a wonderfully flourishing and forward state, some meadows being so heavy already that a shower of rain quite laid them. *Loughbrickland* (G.). The spring abnormally fine and dry. Butterflies scarce. *Londonderry* (G). The farmers say they never remember so favourable a season. Drought generally, but occasional copious timely showers. *Ballynagard* (G.). Very hot and dry season, with very occasional rain, which saved the crops. *Tynron* (H.). Never before recollect seeing roses, brambles, and fox-gloves in bloom in May. *Thornhill* (H.). No injuries from drought, abundance of grass in the pastures. 31st. Two species of heather in bloom. *Jardington* (H.). Grass abundant. Drought not injurious here. *Doddington* (I.). 31st. No grass owing to the drought, and pastures as dry and burnt up as in August. *Driffield* (I.). 11th. Potatoes blackened by frost. 28th.

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First strawberry gathered. *Durham* (I.). Grass improved rapidly after the rains of the 17th. Swallows and swifts plentiful. 5th. Swift first seen. *Low Fell* (I.), Gloire de Dijon rose in flower during the last week. *Cambois* (I.). Oats and hay the only crops injured by drought. *Aberdeen* (I.). One of the driest springs on record, but favourable for preparing ground for seeds. Crops, both field and garden, except hay, most promising. Swallow and cuckoo arrived unusually early. *Inverbroom* (K.). This has been the best spring known for many years, plenty of rains and damp mists. An abnormal quantity of wasps, green fly, caterpillars, &c.

JUNE.—*Marazion* (A.). Strawberry plants produced little or no fruit, owing to drought. *Killarney* (B.). The greater bindweed bloomed 28 days earlier than its average date for the previous 10 years. *Bembridge* (C.). Began cutting meadow hay, very light crop, and carted the next day. *Pennington* (C.). At the end of the month gardeners busy sweeping up leaves. 7th. Haymaking over, sadly deficient crop, 4 tons only carried where 45 tons have been secured in good seasons. 19th. Leaves on limes and planes changing colour and falling fast. *Bidborough* (C.). Black currants have shrivelled and dropped off the bushes owing to drought. *Swanley* (C.). 5th. Ripe cherries sent to market. 12th. Raspberries sent to market. 14th. Black currants sent to market. *Churt* (C.). Owing to the drought, plants flowered abundantly, but very early, and blossoms small. When picked they soon withered. *Addlestone* (C.). Many fruit trees, &c. killed by drought. *Whatley* (C.). Towards the end of the month birds were found dying in the fields for want of food. *Beckford* (D.). 12th. Some meadows mown for hay, others not till August 15th, and many not at all. *Watford* (D.). Grass dried up, cutting the green barley for cattle. *Harpenden* (D.). 2nd. First wheatear observed out of the sheath, this is exceptionally early. In Sir J. B. Lawes' grass experiments at Rothamsted, the plot which never receives any manure yielded 3 cwt. of hay per acre, instead of its usual average of 21 cwt.; and the plot the most heavily manured yielded 28 cwt. per acre, instead of an average of 57 cwt. *Ross* (D.). 8th. Black currants ripe for use. *Burbage* (D.) Grazing pastures a pitiable sight. *Thurcaston* (D.). Hay crop ridiculously small. Flowers over almost as soon as open. *Tean* (D.). 8th. First hay cut. *Hodsock* (D.). 16th. Grass very burnt. *Harrogate* (D.). 18th. Haymaking began, but crops exceedingly light. 21st. Numerous nests of wasps and hornets. *Lexden* (E.). No hay to be cut, the pastures being all dried up and burnt, and no fodder for sheep and stock. *Penmaenmawr* (F.). 15th. Hay harvest began, very thin crops. *Claughton* (F.). 30th. Hay cut. *Tynron* (H.). 2nd. Since recent copious rains the country is looking extremely verdant. *Driffield* (I.). 3rd. Gathered first ½ lb. of strawberries, 32 days earlier than in 1886. 20th. Remarkable profusion of wild rose bloom. *Thirsk* (I.). 20th. Haymaking began. *Low Fell* (I.). Cuckoo and corncrake scarce this year. *Inverbroom* (K.). Wasps, house flies, bluebottle, &c. very numerous.

JULY.—*Falmouth* (A.). Blackberries ripe at end of July, and unusually fine and plentiful. *Killarney* (B.). Mushrooms and wasps in unusual quantity. 27th. Hollyberries red in many places. *Bembridge* (C.). 4th. Clouded-yellow butterflies very abundant. *Buckhorn Weston* (C.). Great numbers of ladybirds, which are rarely seen here at all. *Pennington* (C.). Mushrooms very plentiful for a fortnight in the middle of the month. Wasps a great plague (140 nests destroyed at one place only), and did much injury to cherries, plums, and pears. *Swanley* (C.) 1st. Red and white currants sent to market. 3rd. Early potatoes and apples sent to market. 24th. Plums sent to market. *Addlestone* (C.). Wasps very troublesome. *Whatley* (C.). Butterflies very scarce, notably the small copper. Have seen humming bird moths three times. An enormous number of wasp's nests. *Cheltenham* (D.). The rains rapidly restored the pastures, and a small second crop of hay was well secured. *Beckford* (D.). Began cutting wheat. *Watford* (D.). Birds devoured all our peas, crop after crop. Wasps very abundant. *Berkhamsted* (D.). 4th. When digging up some potatoes in my garden, the ground in which they were growing was found to be dust dry to the depth of 17 ins. *Harpenden* (D.). The seeds of most root crops were in the ground several weeks before they germinated at all, and even after germination the plants made but little growth, until the rains of July moistened the hardened soil. *Walsall* (D.). 11th. Young lime, beech, and elm trees quite

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leafless. Some trees show autumn tints, and the leaves are rapidly falling through drought. 30th. Most trees quite recovered, and have a spring-like appearance. Apple trees with second blossoms on them. *Tean* (D.). After the thunderstorm of the 3rd grass grew rapidly. 26th. Blackberry ripe. *Hodsock* (D.). At end of month grass very green, quite like spring. 26th. Harvest began. *Harrogate* (D.). 8th. Terrible thunder and hailstorm. Some of the large pieces of ice which fell weighed over an ounce. About half the corn crops destroyed, also potato tops. Large slices cut off many apples by the sharp pieces of ice, without bringing the fruit from the trees. *Bocking* (E.). At the beginning of the month the grass was much burnt up and browned, but rapidly recovered in a week or two. *Lexden* (E.). 1st. Lime trees shedding their leaves. *Tacolneston* (E.). Wasps extremely numerous. Apples an enormous crop, and very fine and good. 28th. First wheat and oats cut. *Egremont* (F.). Wasps very numerous. *Jardington* (H.) 28th. Harvest began. *Helensburgh* (H.). 28th. Barley in the stook. *Driffield* (I.). 12th. Wasps very plentiful. *Thirsk* (I.). 20th. Harvest began, and was over in about a fortnight. *Lilliesleaf* (I.). Flycatchers unusually numerous. 29th. Wasps very numerous.

AUGUST.—*Marazion* (A.). Saw some specimens of the clouded-yellow butterfly. *Long Ashton* (A.). 24th. There are sweet peas in our garden blossoming from self-sown seed. *St. David's* (A.). Great scarcity of grass, and stock selling at nominal prices. *Bembridge* (C.) 24th. More clouded-yellow butterflies. Wasps very numerous. *Pennington* (C.). Harvest commenced June 27th, but not over by the end of this month, owing to late sown spring oats and barley not coming on from scarcity of rain. 3rd. Althea Frutex in flower 77 days earlier than in 1892. 10th. Last swift. *Swanley* (C.). 3rd. All corn on farm carried. 18th. Damsons sent to market. *Chislehurst* (C.). 18th. Elms and limes quite yellow, and a great quantity of leaves have already fallen. *Churt* (C.) Grass growing rapidly since the rains. *Oxshott* (C.). Garden produce almost *nil* throughout the summer. Quite a plague of wasps and flies. *Addlestone* (C.) 17th. Fruit crops much injured by wasps. Lawns again brown and bare. *East Molesey* (C.). Grass, which had revived, now worse than ever. Wasps not unusually plentiful. *Whatley* (C.). 28th. Wasps have been very numerous the last few days. Small copper butterfly quite common, but no painted-ladies. 30th. Humming-bird moth numerous. *Oxford* (D.). Wasps almost a plague. *Cheltenham* (D.). Pastures again brown, and the trees are shedding their leaves. Vegetables very scarce. *Beckford* (D.). 30th. Pastures brown and grass dried up. Pools and water courses dry which were never known to fail before. *Berkhamsted* (D.). 1st. Until to-day no measurable quantity of rain water has come through the 2½ ft. of soil in my percolation gauges since March 12th, or for 20 consecutive weeks. *Ross* (D.). Wasps not extraordinarily numerous, less so than in 1846. *Walsall* (D.). Saw several meadow brown butterflies in the garden—first time during eight years. *Hodsock* (D.) By beginning of month hawthorn berries were already red. *Harrogate* (D.). Harvest practically over. *Bocking* (E.). For about a week in the middle of the month there was a perfect plague of wasps. Butterflies not more numerous than usual. *Wryde* (E.). 2nd. Began harvest. 30th. Finished harvest. The worst on record, and no straw for winter use. *Penmaenmawr* (F.). Good crops of corn well harvested. 25th. Cutting second crop of meadow hay. *Giggleswick* (F.). Such a good year for gardens has not been known before in this district. *Edgeworthstown* (G.). No plague of wasps here. *Antrim* (G.). Leaves began to fall early in the month. Butterflies numerous, but no plague of wasps. *Ballynagard* (G.). Butterflies unusually numerous. Crops generally good. *Tynron* (H.). 8th. Wild raspberries nearly over. Mountain ash berries ripe. The drought has not injured the crops. *Driffield* (I.). 4th. Harvest began, or 27 days earlier than in 1891. 18th. Wasps unusually abundant this season. 21st. Trees permanently dropping their leaves. Foliage thin throughout the summer. 31st. Everything injured more or less by dry state of the soil. *Durham* (I.). The second blossoming of flowers was common. Summer flowers and foliage luxuriant, but the blooms lasted no time, and the leaves fell much earlier than usual. *Low Fell* (I.). Wasps very numerous. *Cambois* (I.). More wasps than usual. Potatoes a good and heavy crop.

SEPTEMBER.—*Marazion* (A.). Strawberries produced a considerable quantity of ripe fruit. *Mawnan Smith* (A.). 23rd Gathered two ripe wild strawberries.

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St. Arvan's (A.). 24th. Grass lands dried up. *St. David's* (A.). The long drought did not damage wheat crop, nor potatoes and turnips. *Killarney* (B.). 15th. Delphiniums, perennials, phloxes, apples, bay, horse-chestnut, and dog rose flowering a second time. Horse-chestnuts quite ripe. 21st Laburnum in flower (three specimens sent). *Bembridge* (C.). Many trees and shrubs, the shoots of which had become ripened and rested during the hot weather, were started into growth again by the recent rains. Many apple and pear trees flowered. A syringa grandiflora blossomed from this year's wood. Mushrooms very plentiful. Carrots, beets, and onions a complete failure, owing to seed not germinating when sown. 24th. Wasps very numerous. *Buckhorn Weston* (C.). The wild roses, and also Scotch roses, are blooming again, while the dog-wood is in full blossom, with ripe berries. *Pennington* (C.). Hips, haws, and acorns very plentiful. An apple tree with several blooms on it. *Strathfield Turgiss* (C.). Scarcity of wild flowers, nearly all having bloomed so much earlier than usual, seed pods taking the place of blossoms. Many plants have blossomed twice, and even thrice, *e.g.* dog-wood. Butterflies have been very numerous. More acorns on the oaks than I have ever seen before. *Chislehurst* (C.). A great quantity of humming bird moths. *Cranleigh* (C.). 5th. Gathered strawberries from old plants. Apples small owing to drought. *Addlestone* (C.). 26th. Second crop of strawberries ripe. 30th. Red-admiral butterflies abundant. *Farley* (C.). 23rd. Dahlias killed by frost. *Salisbury* (C.). Wild fruits unusually abundant. The cornel was nearly as fully in flower as in spring. 26th. Dog rose in flower again. *Cheltenham* (D.). By the end of the month the foliage of most trees had become very thin. *Watford* (D.). Pastures very dry. Very few flowers in the garden, soil so dry and parched. *St. Albans* (*The Grange*) (D.). Many more species than usual flowered a second time. Wild roses and dog-wood bearing blossoms and mature fruit together. Never before remember comfrey flowering so freely as it has done this autumn. *St. Albans* (*Addiscombe Lodge*) (D.). 9th. Dog rose again in flower *Brenton* (D.). 20th. Leaves already falling, and meadows on gravel soil brown and bare. *Walsall* (D.). 1st. Last field of wheat carried.. 9th. Acorns and sloes more abundant than the oldest inhabitant remembers. 21st. Saw perfectly leafless laburnums covered with blossom. 23rd. Trees half bare. Lovely autumn tints. 30th. Ripe strawberries gathered. 31st. Dahlias killed. *Tean* (D.). 5th. A third crop of hay was cut from the same field that was first mown on June 8th. 16th. Wild rose in flower again. *Macclesfield* (D.). 1st. Lime trees losing their leaves. 30th. The same trees a mass of golden foliage, though many leaves have fallen. *Harrogate* (D.). 3rd. Great mullein, foxglove, cowberry, laburnum, privet, clematis, and snowberry are flowering a second time. 17th. Enormous quantities of acorns are now fully ripe. 25th. Wild roses blooming at 500 ft. above sea-level. *Bocking* (E.). 3rd. Grass beginning to look brown again. *Sproughton* (E.). A peculiarity of the universally observed plague of wasps was their sudden and almost total disappearance about the middle of the month. *Ambleside* (F.). Many flowers have blossomed a second time. *Cronkbourne* (F.). 15th. Ripe strawberries gathered, and laburnum in bloom. *Saintfield* (G.). Some blackberries which have ripened their fruit are in flower again. Apples, &c. also in blossom. *Antrim* (G.). Strawberries bloomed a second time, and a few raspberries ripened. Never remember so many fine apples, or so many small ones. *Driffield* (I.). Birds attacking apples, owing to dry weather. Great crop of wild rose hips. *East Layton* (I.). 8th. Very severe hailstorm, grouse and partridges killed by the hailstones. Swallows have been unusually numerous. *Aberdeen* (J.). Crops of all kinds came early to maturity, and were secured in excellent condition, with good straw and very heavy grain.

OCTOBER.—*Mavnan Smith* (A.). 2nd. Some birches and sycamores bare of leaves. 4th. Hollies thick with berries. All berries plentiful and fine. 19th. Dog roses in flower. 27th. Hazel in flower. *Falmouth* (A.). Raspberries and strawberries have yielded a good crop. Raspberries 10d. a quart in the market. *Tiverton* (A.). Immense quantities of apples, pears, plums, and nuts this year. Raspberries for sale in the market during the month ending October 25th. On that day I bought them at 6d. a pound, and good flavoured. 2nd. Privet, dog-wood, and field rose in flower. 31st. Saw a field gay with poppies. *Instow* (A.). 31st. Gathered two or three dozen ripe raspberries of good flavour. Holly

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berries exceptionally abundant this year. *St. Arvan's* (A.). Horse and Spanish chestnuts and acorns abundant. 22nd. Gathered ripe raspberries. 31st. Dahlias killed. *St. David's* (A.). Apple trees bloomed a second time, and fruit was formed. Mushrooms abundant. All the meadows fresh and verdant. *Aberystwith* (A.). 11th. Spanish chestnuts have ripened their fruit, which is unusual here. *Pennington* (C.). The late leaf shedding trees, such as oaks, beeches, and sycamores, retained their leaves well, and their autumn tints were fine. Jerusalem artichokes flowered. 7th. Dog rose and guelder roses again in flower. *Chislehurst* (C.). 14th. Several ripe strawberries. *Coneyhurst* (C.). 10th. Sand martins last seen. *Churt* (C.). Exceptionally heavy crop of pears, and fruit fine. Many apples very large, one weighed 19 ozs. Some young seedling dahlias have come up out of doors from the droppings of this year's seeds. 31st. Dahlias killed by frost. *Addlestone* (C.). 29th. Runner beans killed. *Cheltenham* (D.). Very few autumn wild flowers except poppies, which bloomed freely up to the end of the month. Berries very plentiful. *Watford* (D.). Poppies and charlock in full bloom. *St. Albans* (*Addiscombe Lodge*) (D.). Several flowers noticed on a guelder rose bush. *Ross* (D.). Second leafage noticed on larches. 14th. Horse-chestnut in blossom. *Hodsock* (D.). Autumn colouring of trees very fine by the middle of the month, but some trees bare. 30th. Dahlias killed. *Macclesfield* (D.). 1st. Horse-chestnut almost bare of leaves. *Harrogate* (D.). 5th. Rhododendrons flowering a second time. 10th. Mushrooms again abundant. *Hertford* (E.). The cornel has had a second crop of flowers, also dog and field roses. Sloe bushes seem especially to have suffered from the drought, from many the leaves are falling. *Tacolneston* (E.). Many plants flowered a second time, for instance a group of wild water lilies; wild roses also flowered in places. *Antrim* (G.). 17th. A wild rose in blossom. *Ballynagard* (G.). 15th. Dog roses and strawberries in bloom. 27th. White ox-eye again in flower. *Thirsk* (I.). Autumn tints unusually fine. 22nd. Gathered a wild rose. *Durham* (I.). 31st. Dahlias killed by frost. *Cambois* (I.). Hawthorn in bloom, and a second crop of strawberries gathered.

NOVEMBER.—*St. Arvan's* (A.). 12th. Many springs not known to fail before have become dry. *St. David's* (A.). The heavy gales brought a large deposit of salt to the lands, which destroyed much grass and seriously damaged rape and turnips. *Aberystwith* (A.). 5th. Daphne mezereum in flower. *Bembridge* (C.). 11th. Clouded-yellow butterfly seen. *Pennington* (C.). Oak leaves still holding on in many places at the end of month. Springs and wells remarkably low. *Chislehurst* (C.). 5th. Several ripe raspberries. *Oxshott* (C.). The grass never recovered from the drought, most fields still yellow instead of green. *Addlestone* (C.). 30th. Oaks and beeches retained their leaves longer than usual. Fine autumn tints. *Cheltenham* (D.). Apples and pears seem to have ripened too hurriedly, and are rotting very fast instead of keeping —many rotted on the trees. *Edgeworthstown* (D.). 1st. Laburnum in bloom. *Helensburgh* (H.). 17th. Numbers of trees blown down during the gale. *Driffield* (I.). 15th. Springs lower now than for 40 years. *Inverbroom* (K.). The most stormy and windy autumn ever remembered.

DISCUSSION.

THE PRESIDENT (Mr. R. Inwards) said that probably very few persons had any idea of the amount of correspondence and information which had to be dealt with in the preparation of this report, and the thanks of the Society were due to Mr. Mawley for the labour bestowed in its compilation, and also to the observers who had supplied the necessary material.

Mr. H. SOUTHALL said that Mr. Mawley's report dealt so fully with the remarkable season of 1898, that there was hardly room to add anything to so clear and complete a summary. His own experience of the effects of the weather of 1898 on the plants, chiefly herbaceous, in his garden, very closely corresponded with what was described in the report. A striking feature in the phenology of last year was the remarkably quick flowering of plants after the break up of the frost of January. Cyclamen coum was the first to appear in bloom, although this was by no means considered to be a hardy plant, but the frost destroyed many plants usually regarded as of a hardy character, and was

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especially fatal to plants coming from the Cape of Good Hope. People had said that the abundance of flowers in spring would result in a scarcity of summer blossoms, but his own experience was quite contrary to this statement, there being a continuous succession of flowers throughout the season. The drought appeared to have seriously affected evergreens, especially those varieties which were shallow-rooted, and probably the injurious effects of the abnormal dryness was not yet fully known, but on the whole the effect of the weather of 1893 upon horticulture would, he thought, prove to be beneficial. It was a great advantage to have accurate accounts of the effects of atmospheric conditions upon phenological phenomena, and Mr. Mawley's report supplied such information.

Mr. F. J. BRODIE said that mention had been made in the report of a second drought in August, but he was not aware that any drought prevailed at that time. Was this dry period a "drought" according to Mr. Symons' definition?

Mr. C. HARDING bore testimony to the valuable information to be gleaned from Mr. Mawley's reports, and said that the weather in the various districts often differed considerably; and the year 1893 had been no exception in this respect, for while in the south-eastern districts, the year had, with the single exception of 1868, been the driest on record, the west of Scotland had experienced the wettest year, excepting one, ever known. Considered horticulturally, last year (1893) was undoubtedly exceptional, but the present year (1894) promised to be more remarkable still, for fruit trees and vegetation in general were fully a month in advance of their average condition at this early period of the year.

Mr. F. C. BAYARD thought that the wet weather of February might have influenced the flowering of the hazel and caused it to be later than the average.

Mr. E. MAWLEY, in reply, said that in speaking of the dry weather of August as the "August drought" he was describing it as a horticulturist rather than a meteorologist, for although it may not have been a drought according to the definitions adopted by Mr. Symons, it seriously affected vegetation. The destruction to certain plants caused by the winter of 1892-3 was somewhat remarkable, all the montbretias and globe artichokes which had remained in his garden uninjured for eight years, and which were unprotected except to the extent of a little "earthing up," having been killed. The dates of flowering of the hazel may have been retarded by the wetness of February, but the dulness of the month probably exerted a greater influence in causing the blossoming to be later than usual. The greatest satisfaction he had felt in preparing this report was concerning the curves of average flowering, which for many of the plants are even smoother than in the two previous years.

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TEMPERATURE, RAINFALL, AND SUNSHINE, AS RECORDED DURING THE PAST FIVE YEARS AT LAS PALMAS, GRAND CANARY.

By J. CLEASBY TAYLOR, M.D.

(Plate III.)

[Received October 17th, 1893—Read February 21st, 1894.]

The islands of the Canary Archipelago are almost entirely situated between the 28th and 29th degrees north of the Equator, so that difference of latitude does not enter into any of the questions relating to the various climates of the group.

It is different with the longitude, as the islands extend over five degrees; the most eastern islands being within 60 miles of the African coast, whilst the western are 800 miles away. This fact modifies the aspect, climate, flora, crops, etc., making the eastern part of the group African, and the western part Atlantic in character.

In addition to this general factor there are local ones affecting different localities. These are the position and height of the mountains; the northern slopes experiencing more cloudy weather and greater rainfall than the southern. This is more noticeable in those islands in which the mountainous ridges rise quickly to a great altitude.

The island of Grand Canary occupies a position midway between the African Continent and the most western islands. (Plate III.) The mountain peaks rise to a little over 6,000 feet, and they are about 20 miles from the litoral (in a horizontal line). For this latter reason the litoral is somewhat free from the influence of the mountains. And from its position the chief town and port of the island, Las Palmas, is particularly free. The town is exposed from north-west, through north and east to south, and sheltered from the south-

TABLE I.—Mean Maximum and Mean Minimum Shade Temperatures.

Months.	Mean Maximum.							Mean Minimum.						
	1888.	1889.	1890.	1891.	1892.	1893.	Mean.	1888.	1889.	1890.	1891.	1892.	1893.	Mean.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°
January ..	..	65·2	67·0	65·2	68·5	68·5	66·9	..	57·4	57·5	57·0	58·7	58·6	57·8
February ..	..	66·2	66·9	67·1	70·2	70·0	68·1	..	57·8	57·8	56·2	60·0	57·9	57·9
March	..	66·7	64·7	69·9	69·6	70·8	68·3	..	59·5	57·6	58·3	58·7	60·3	58·9
April	..	65·8	67·8	71·0	70·5	70·8	69·2	..	58·8	60·1	60·6	59·6	61·0	60·0
May	..	69·7	69·4	70·7	72·0	73·6	71·1	..	62·1	63·0	62·8	63·0	63·6	62·9
June	..	..	72·0	74·6	74·3	76·1	74·2	..	..	65·4	66·8	66·2	68·5	66·8
July	..	..	72·2	78·1	78·0	78·0	76·6	..	..	66·5	70·0	70·0	71·0	69·4
August	..	..	..	80·0	78·5	81·1	79·8	..	..	..	69·6	70·8	72·5	71·0
September ..	..	..	76·3	78·0	78·8	80·6	78·4	..	..	67·8	68·0	69·3	71·4	69·0
October	78·0	73·0	75·8	76·2	76·9	80·0	76·6	67·7	65·3	67·3	67·4	66·6	68·5	66·8
November ..	72·8	71·5	71·2	71·8	73·2	75·0	72·6	63·6	63·3	62·8	62·7	63·8	64·8	63·2
December ..	68·7	66·8	67·3	70·7	70·3	70·9	69·1	60·8	58·6	58·2	61·0	60·2	61·7	59·7

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TABLE II.—Absolute Maximum and Absolute Minimum Shade Temperatures.

Months.	Absolute Maximum.						Absolute Minimum.					
	1888.	1889.	1890.	1891.	1892.	1893.	1888.	1889.	1890.	1891.	1892.	1893.
	°	°	°	°	°	°	°	°	°	°	°	°
January	..	67·5	71·0	71·0	78·5	73·5	..	55·0	54·5	51·5	56·5	51·5
February	..	72·5	74·5	71·0	75·5	73·5	..	54·5	53·5	52·0	57·0	55·0
March	..	72·0	72·0	75·0	82·0	81·5	..	56·5	51·5	54·5	55·0	55·0
April	..	69·0	71·5	82·0	76·5	74·0	..	53·5	56·0	58·5	56·0	55·0
May	..	77·0	80·0	80·0	77·0	78·0	..	58·0	57·0	59·5	56·5	59·0
June	..	..	81·5	77·5	77·5	81·5	..	..	61·5	64·5	61·0	65·0
July	..	..	76·0	83·0	81·5	80·5	..	..	64·5	67·5	67·5	68·5
August	..	..	..	85·5	82·0	85·5	..	..	..	67·5	68·5	68·0
September	..	..	82·5	81·0	80·0	85·0	..	..	65·5	66·0	65·0	68·0
October	85·5	77·5	80·0	81·5	80·5	95·0[1]	62·5	58·0	65·0	63·0	63·5	65·0
November	75·5	74·5	74·5	79·5	77·5	82·0	58·5	61·5	58·0	58·0	59·5	58·0
December	73·5	70·5	72·5	76·0	76·0	81·5	57·0	52·5	53·5	57·5	55·0	55·0

[1] South Wind.

TABLE III.—Air and Sea Temperature.

Months.	Mean Air Temperature. (Mean of Max. and Min.)							Mean Sea Temperature at Noon. (3 feet below Surface.)						
	1888.	1889.	1890.	1891.	1892.	1893.	Mean.	1888.	1889.	1890.	1891.	1892.	1893.	Mean.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°
January ..	..	61·3	62·2	61·1	63·6	63·5	62·3	..	66·7	64·1	64·2	66·6	66·9	65·7
February ..	..	62·1	62·7	61·7	65·1	63·9	63·0	..	65·0	63·9	63·9	66·0	66·5	65·1
March ...	..	63·7	61·1	64·3	64·1	65·2	63·7	..	65·8	63·3	65·2	66·0	66·8	65·4
April	..	62·8	62·0	65·8	65·0	65·9	64·6	..	64·6	64·5	66·5	66·6	67·6	65·9
May	..	65·9	66·2	66·7	67·5	68·6	66·5	..	66·7	65·4	67·8	67·1	69·4	67·3
June	..	..	68·7	70·7	70·2	72·3	70·5	..	..	68·1	69·9	69·9	71·4	69·8
July	..	..	69·3	74·0	74·0	74·5	73·0	..	..	70·0	73·0	72·1	73·0	72·0
August	..	..	..	74·3	74·6	76·8	75·4	..	..	71·6	74·3	72·8	74·8	73·4
September..	..	..	71·2	73·0	74·0	76·0	73·8	..	..	72·1	74·5	73·5	76·4	74·1
October	72·8	69·1	71·5	71·8	71·7	74·2	71·8	72·8	70·3	72·7	73·0	73·5	74·4	72·8
November ..	68·2	67·3	67·0	67·3	68·5	69·9	68·0	70·1	69·9	69·6	70·7	70·5	71·6	70·6
December ..	64·7	62·7	62·7	65·8	65·2	66·3	64·6	68·7	66·0	66·9	68·2	67·8	67·8	67·6

TABLE IV.—Rainfall.

Months.	Total Rainfall.							Greatest Rainfall in 24 hours.					
	1888.	1889.	1890.	1891.	1892.	1893.	Mean.	1888.	1889.	1890.	1891.	1892.	1893.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
January ..	1·875	·330	·565	2·205	3·430	1·681	..	·435	·160	·200	·880	2·220
February ..	·775	·630	·917	·405	·155	·576	..	·190	·360	·435	·240	·130
March ..	..	·150	2·870	·225	·140	·575	·792	..	·060	·840	·090	·120	·120
April	..	·332	·030	·200	1·060	·395	·404	..	·200	·030	·070	·600	·150
May	..	·250	1·100	·130	·230	·020	·346	..	·080	·970	·070	·190	·020
June	..	..	·000	·000	·110	·030	·035	..	..	·000	·000	·060	·020
July	..	..	·000	·100	·000	·120	·055	..	..	·000	·100	·000	·100
August ..	..	..	·000	·002	·000	·050	·013	..	..	·000	·002	·000	·050
September	..	..	·050	·010	·577	·285	·232	..	..	·040	·010	·577	·100
October ..	·055	1·340	3·000	·500	·425	·380	·950	·045	·745	2·070	·285	·225	·200
November	1·105	1·465	2·660	2·465	1·070	1·065	1·638	·305	·630	1·580	·700	·430	·430
December	1·575	2·545	2·235	·230	1·305	3·245	1·856	·345	·740	·290	·080	·255	1·165

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TABLE V.—Sunshine (Jordan Recorder.)

Months.	Total Sunshine.							Percentage of Possible Duration.						
	1888.	1889.	1890.	1891.	1892.	1893.	Mean.	1888.	1889.	1890.	1891.	1892.	1893.	Mean.
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	%	%	%	%	%	%	%
January ..	..	137	203	153	171	178	168	..	43·4	62·0	47·0	52·4	54·4	51·9
February ..	..	167	161	210	187	194	183	..	53·1	51·2	66·8	59·2	62·1	57·7
March	..	193	135	237	172	211	189	..	52·0	36·5	64·0	49·9	56·7	51·6
April	..	140	186	220	198	209	190	..	36·5	48·7	57·8	51·6	54·6	49·9
May	..	212	195	204	256	223	218	..	50·6	46·8	48·6	60·2	53·4	51·9
June	..	..	172	238	171	252	208	..	..	41·0	56·4	40·2	60·3	49·5
July	..	..	109	227	208	145	172	..	..	25·4	53·3	48·7	34·1	40·4
August	..	..	..	214	166	214	198	..	..	..	52·7	38·8	52·6	48·0
September	..	..	196	203	214	215	207	..	..	53·0	54·6	57·8	57·8	55·8
October	..	154	164	167	200	187	174	..	43·7	46·5	47·3	56·5	53·1	49·5
November ..	166	186	165	146	154	159	162	57·9	58·0	51·5	45·6	48·1	49·5	52·1
December ..	129	137	185	191	165	138	157	40·5	43·0	58·3	59·7	51·1	43·4	49·3

TABLE VI.—No. of Rainy and Overcast Days.

Months.	No. of Days of Rain.							No. of Overcast Days. (Days with less than 1 hour's sunshine.)						
	1888.	1889.	1890.	1891.	1892.	1893.	Mean.	1888.	1889.	1890.	1891.	1892.	1893.	Mean.
January ..	..	20	4	6	11	10	10	..	2	1	6	1	3	3
February ..	..	10	6	4	4	2	5	..	2	2	0	2	4	2
March	..	4	16	4	2	10	7	..	1	7	1	4	1	3
April	..	6	1	3	7	5	4	..	1	3	0	1	2	1
May	..	5	3	2	2	1	3	..	2	5	3	1	2	3
June	..	..	0	0	3	2	1	..	..	4	1	2	0	2
July	..	..	0	1	0	2	1	..	..	9	2	1	10	5
August	..	..	0	1	0	2	1	..	..	..	1	5	1	2
September	..	..	2	1	1	4	2	..	..	4	0	0	2	2
October	3	13	6	5	4	5	6	..	0	2	3	3	2	2
November ..	11	9	12	14	9	9	11	3	2	1	2	2	5	3
December ..	14	17	16	4	9	10	12	4	4	1	0	2	7	3

west and west. For these reasons its meteorological conditions may be considered to approach more closely to those common to this portion of the globe.

As it is impossible within the limits of a short paper to enter into all the details, the shade temperature, the sea temperature, the rainfall, and sunshine are alone considered.

The thermometers for recording the shade temperature were exposed in a Stevenson screen situated in the centre of an extensive flat roof. The temperature of the sea was recorded by an ordinary bath thermometer immersed in the sea at the end of the town mole. It was recorded as near noon as possible, at a depth of 3 feet from the surface and in never less than 20 feet of water, usually much more. The number of observations ranged from ten to fifteen per month. The rain gauge was exposed on the flat roof, which was the highest in the neighbourhood. The sunshine was recorded by means of Jordan's photographic sunshine recorder.

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In giving these results I quite recognise that five years' observations (June, July, and September, four years; August three years) are a very short period from which to draw very definite conclusions.

The means of shade temperature show a gradual ascent and a more rapid descent, due principally to the little variation for the months of January, February, and March. In fact, the curve of ascent from April to August closely corresponds to the curve of descent from August to December.

The period of highest temperature occurs in the month of August, the highest mean temperature taking place during the third week. The decrease in the fourth week is due to the fall of the minimum or night temperature; as the maximum or day temperature remains practically stationary during this fourth week.

The 16th and 17th are the hottest days, though the average is rather higher on account of the temperatures recorded in August 1893.

August 1893.	14.	15.	16.	17.	18.	19.	20.
Maximum	80°·5	82°·0	84°·5	85°·5	81°·5	81°·5	80°·5
Minimum	72°·5	72°·0	75°·0	74°·0	72°·0	73°·0	73°·5

The temperature of the sea is at its highest level during August and September, but it does not remain at this point for more than three weeks, when it commences to fall. During this period it approximates to the minimum, being the greater part of the time lower than the mean shade temperature. The temperature of this period for one year naturally varies from another, the period of the highest level also shows variations, though if the temperature has not fallen by the end of September the first week of October shows a decline.

TEMPERATURES OF THE SEA (MEANS) AT NOON.

July 31st (4 years)	Sept. 1st (4 years)	Oct. 1st (6 years)	Nov. 1st (6 years)	Dec. 1st (6 years)
72°·9	74°·1	73°·6	71°·7	68°·9

The *Rainfall* of this period is practically *nil*.

The *Sunshine* is remarkably regular with the exception of the second week in August, for which I am not in a position to venture a reason. This fall appears to affect the course of the maximum but not of the minimum temperature.

The *Winds* during these two months prevail continuously from the North to North-east, and their force is 3—4.

During October the temperatures, both of the shade and of the sea, fall considerably; this is particularly so with the shade temperature of the daytime, and this varies according to the time of commencement of the rainy season and the number of days on which rain falls, the amount of sunshine remaining fairly constant, though the sun's rays grow less powerful.

The period of greatest fall in temperature is during the months of November and December, coincident with the period of greatest fall in the sea temperature and with the period of heaviest rainfall; the amount of sunshine

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remaining fairly constant. During January the fall in shade temperature continues. This is also a rainy month, though by the latter end of the month the day temperature shows an upward tendency, as the rays of the sun are again increasing in power, but the night shade temperature and the sea temperature still decrease.

The coldest period of the year commences in January, and continues through February to March, though the periods do not correspond at which the day temperature, the night temperature, and the sea temperature are at their lowest points.

The lowest point of the maximum temperature (that is the temperature of the day) occurs about the third week in January, after which it rises, but the minimum or night temperature does not commence to rise till the second week in February, thus following the curve of the sea temperature. The shade temperatures at noon (G. M. T.) and at 9 p.m. follow respectively the maximum and minimum.

From the detail of five years, the lowest temperature is recorded for the day time during the third week of January; after this date the day temperature continues to rise even with occasional fluctuations, but the minimum or night temperature does not show any tendency to rise till the middle of February, which epoch is coincident with both increase of day temperature and sea temperature.

The connection between sea temperature and night temperature is well seen from the following:—

Weeks.	January.					February.				March.			
	1–7.	8–14.	15–21.	22–28.	29–4.	5–11.	12–18.	19–25.	26–4.	5–11.	12–18.	19–25.	26–31.
Temp. 9 p.m. ..	60°5	60°8	61°0	60°4	59°8	59°5	61°1	61°8	61°8	61°0	62°0	61°4	62°7
,, Minimum	57°6	57°5	58°0	57°5	57°7	56°7	57°5	59°0	59°1	58°3	58°6	59°2	59°8
Sea Temperature	66°2	65°8	65°6	65°3	65°2	65°1	65°1	65°0	65°2	65°5	65°5	65°5	65°7

The monthly variation in temperature at this season is slight; the rainy season comes to an end in January, the temperature of the sea is at its lowest point, but the power of the sun is increasing, though the amount registered does not differ to any great degree (February excepted).

The chief rise in the temperatures takes place in the three months April, May, and June.

The mean diurnal variation in temperature is not great; May, June, July, and August show the slightest degree, with a mean of 7°·7 against 9°·5 for the first four months and 9°·3 for the last four. By 9 a.m. the shade temperature has risen 5° or 6° from the minimum, by noon 2° or 3° more, the maximum being reached somewhere about 1 p.m.: by 3 p.m. it has fallen 2°, and by 9 p.m. it is within 2° of the minimum temperature. Although I have no statistics, two maxima and two minima may be found; the first maximum is reached about 8 a.m. and is more marked on a bright sunny morning with little wind. As the breeze freshens between 9 and 10 a.m., the temperature

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falls only to rise again towards noon. The first minimum is seen soon after sunset, but between 8 and 9 p.m. the temperature rises very often 8°, but towards midnight a fall commences and the absolute minimum is reached just before sunrise.

There may be a great rise in temperature during the evening, but it is very rare: thus on October 15th, 1898, between 8 p.m. and midnight, there was registered a rise of 9°·7.

October 15th, 1893.	12 Noon.	1 p.m.	2 p.m.	3 p.m.	4 p.m.	5 p.m.	6 p.m.
Shade Temperature	89°·0	87°·5	86°·0	85°·0	85°·0	75°·5	74°·5
Direction—Force of Wind....	SSE 3	..	..	SSE 3	..	WNW 1	..
Barometer	30·00	..	..	29·95	..	..	29·98

October 15th, 1893.	7 p.m.	8 p.m.	9 p.m.	10 p.m.	11 p.m.	12 Midnight.
Shade Temperature.....	74°·5	73°·0	75°·0	78°·0	81°·0	82°·5
Direction—Force of Wind.....	W 2	W 2	Nil	SSE 2	SSE 2	SSE 2
Barometer	..	..	30·00	29·98	..	29·97

This day was very exceptional both in temperature and humidity, and on this day there were two distinct maxima and minima.

Oct. 15th	9 a m.—9 p.m.	90°·5 (11.30 a.m.)	78°·0 (8 p.m.)
Oct. 15th-16th	9 p.m.—9 a.m.	88°·0 (midnight)	71°·5 (6 a.m.)

The diurnal range varies considerably with the variations in wind and sunshine. With a South wind (that usually dies down at sunset) the range is increased, but the greater part of the increase of range is in the day temperature. With the Northerly winds persisting after sunset the range may be very slight, particularly if the day has been cloudy. I have taken as examples the same period of years, and both periods may be considered exceptional.

Date.	Sunshine. Daily Average.	Shade Temperatures. Max.	Min.	Range.	Mean.
	h. m.				
March 1889–1893. Mean..	6 30	68°·3	58°·9	9°·4	64°·2
Feb. 27–March 5, 1893. ,, ..	10 00	75°·1	60°·7	14°·4	67°·9
March 1–6, 1890. ,, ..	0 00	60°·9	55°·1	5°·8	58°·2
Extreme Variation ..	..	14°·2	5°·6	..	..

The temperatures of the different localities situated at sea-level vary considerably, the day temperature depending chiefly on the local cloud and consequent obscuration of the sun, the night temperature on the persistence or otherwise of the prevailing winds. Both of these conditions are due mainly to the position, proximity, and height of the mountains.

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Locality.		Mountain Ranges.		Effect of Position of Mountains.		Aspect.	Diurnal Range.
		Proximity.	Height.	Sheltered from.	Exposed to.		
Town.	Island.		Ft.				About.
Santa Cruz, de la	Palma	Close	7000	SW, NW	N, E, S	E	° ° 14—15
Puerto, Oratava,	Tenerife	Close	7000	ENE, S, W	WNW, N, NE	N	12—14
Santa Cruz de	,,	Close	4000	SW, NW	N, E, S	SE	12—13
Las Palmas,	Grand Canary	20 miles off	6000	SW, W	NW, N, E, SE, S	E	9—10

Vegetation may play some part in the case of the two former places, but the country around the latter two is barren, and more so round Las Palmas than Santa Cruz.

The low range at Las Palmas is mainly due to the continuance of the prevailing winds (Northerly) after sunset. In the other places this Northerly wind tends to die down (locally) and is replaced by a land breeze. In Las Palmas, on those days when there is a great range of temperature, a land breeze from the West is usually noticed.

The sea temperature has been already alluded to, and the detail for Las Palmas is given in Table III. From personal observation it appears to be the same at all the islands; though running along the African coast there is a belt of colder water. This may be very slightly felt at Lanzarote and Fuerteventura. This cold current is inhabited by fish that are not caught off the islands: the catching and salting of these fish form one of the staple industries of the more eastern islands.

The sea temperature around the islands is dependent on causes outside the limits of the archipelago; local presence or absence of sunshine does not cause any difference, a boisterous Northerly wind with a high sea may cause the temperature to fall quicker than usual, or if the temperature is rising to check the rise, but any sudden variation is very rare. As pointed out, the temperature rises the most in May and June, and falls the most in November and December; whether the rainfall through the last three months of the year accounts for this fall it is not easy to say. There is a certain connection between the rainfall and fall of sea temperature, but both are probably due to stormy weather to the northward; this in turn affects the temperature without the sunshine being affected. This may be seen from the table on p. 161.

From Tables IV. and VI. it will be seen that the rainfall for Las Palmas is not great, though it is spread over a large number of days, the average yearly amount being 8·57 ins. Nearly half of this, viz. 4·06 ins., falls on 12 out of the 62 days on which rain is recorded, thus leaving 4·50 ins. to fall on the remaining 50 days. Out of the 8·57 ins. 3·34 ins. falls during the day-time and 5·22 ins. during the night time; naturally rain also falls more frequently during the night time than during the day time, as rain was recorded

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Years.	Oct.–Dec. Rainfall.		Temperature of Sea.			October to December.		
						Sunshine.	Shade Temperature.	
	Amount.	No. of Days.	On Oct. 1st.	On Jan. 1st.	Amount of Fall.	Hours.	Noon, G.M.T.	9 p.m.
	Ins.		°	°	°		°	°
1888	2·735	28	74·0	67·8	6·2	495	72·2	67·3
1889	5·348	39	71·5	64·0	7·5	477	69·5	65·6
1890	7·895	34	72·5	65·5	7·0	514	70·3	65·3
1891	3·195	23	74·0	67·0	7·0	504	71·8	66·4
1892	2·800	22	74·0	67·0	7·0	518	71·6	66·4
1893	4·690	24	75·5	66·5	9·0	484	73·1	66·9

as falling on 33 occasions during the daytime with 47½ for the night time, this being the annual average for the five years.

The greater part of the rain falls in October, November, December, and January. For February there is a considerable diminution, with slight increase in March, but the amount further diminishes in April and May, whilst June, July, and August are practically rainless, and September is very similar, the average for this month being almost entirely supplied by one heavy shower. This periodicity of the rainfall, and the slight influence it has on the amount of sunshine, can be well seen from the following figures:—

Period.	No. of Days.	Rainfall.		Sunshine.		No. of Cloudy Days.
		Amount.	No. of Days.	Average Daily Amount.	Percentage.	
		Ins.		h. m.		
October to January.....	123	6·115	38·6	5 25	50·7	9·1
February to May	120	2·118	19·4	6 37	52·2	8·8
June to September	122	·335	4·1	6 22	48·4	11·4

The smallness of the rainfall of Las Palmas is in a great measure due to the absence of the mountainous influence, the major part of it being regulated by the influences of the weather out at sea. The rainfall at sea for this region is of two varieties, one is that associated with the Northerly set of winds. This is the commonest variety, and this rain falls in short sharp showers, very local in character, the weather before and after being fine. These showers can often be seen approaching or passing at some little distance, and are usually heralded by a temporary increase in the force of the wind. The other variety of rainfall is associated with disturbances to the south-west; these are rare, as the eastern islands are somewhat out of the track of these squalls. The rain, however, is of a heavy tropical character, and may be associated with electric phenomena. I have never yet seen a disturbance passing from the north connected with electrical phenomena.

From Table V. the amount of sunshine can readily be ascertained. Depending on the amount of clouds, it may be diminished by general cloudy weather or by the local formation of clouds, though the degree of the latter may often be in proportion to the former. In the case of Las Palmas the sunshine of

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the afternoon is often affected by this local cause, as the sky may be fairly clear overhead, yet no sunshine is recorded because the sun has sunk behind masses of clouds that overhang the elevated northern parts of the island to the west of the town.

Excluding February and July, the amount recorded is very regular, being 51·5 per cent. February has 58 per cent. and July 40·5. The number of totally cloudy days—days with one hour's sunshine or less— are not many, for according to Table VI. the average annual number is about 30, the month of July having the largest number. As I have pointed out, the rainfall has little in common with the sunshine. This is dependent on the winds, particularly on the force of the prevailing winds (Northerly), as the greater the force of the Northerly winds there is more liability to both general and local cloudy weather, the "parasol" of clouds hanging more densely over the northern part of the island. With the Easterly and Southerly winds the sky is usually cloudless, but with the South-west winds it is overcast.

In the present paper it is impossible to go into the question of humidity, as it is associated with the winds and this with the barometric pressure. I might briefly point out that the rainless period shows a higher degree of humidity than the rainy periods, and thus corresponds more with the diminution of sunshine. This is seen from the following table:—

Means.	No. of Days.	Rainfall.		Sunshine.		Relative Humidity.			
		Amnt.	Days.	Percentage.	No. of Cloudy Days.	9 a.m.	Noon.	3 p.m.	9 p.m.
		Ins.		%		%	%	%	%
Oct. to Jan.	123	6·116	38·6	50·7	9·1	68·6	65·6	(66·7)	74·5
Feb. to May	120	2·118	19·4	52·2	8·8	66·6	64·6	(65·8)	74·7
June to Sept. ..	122	·335	4·1	48·4	11·4	69·0	68·2	(70·0)	76·9

The humidity observations for 8 p.m. are not so extensive as those for the other hours, being the means for three years only.

NOTE ADDED MARCH 1894.

I cannot enter into the subject of the winds and the weather connected with them. This would require a separate paper. I might however, indicate by means of the table on the next page the average direction of the wind at noon (G. M. T.) and at 9 p.m., and with this I must bring this long paper to a close.

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DIRECTION OF WIND. NUMBER OF TIMES OBSERVED. MEANS FOR 5 YEARS.

Months.	Noon (G. M. T.)						9 p.m.					
	NW., N. & NE.	E.	SE. & S.	SW.	W.	Calm.	NW., N. & NE.	E.	SE. & S.	SW.	W.	Calm.
January....	15·7	2·8	7·5	..	..	3·6	15·0	·6	2·3	..	6·6	6·4
February ..	13·5	4·5	8·2	..	..	1·7	15·4	·6	·6	..	4·6	7·0
March	20·2	5·2	5·2	..	..	·2	21·8	·4	·1	..	3·8	4·6
April	26·4	1·0	2·0	..	..	·5	25·8	..	..	..	1·8	3·0
May	27·5	2·6	·6	..	..	..	27·1	..	..	..	·4	3·5
June	29·0	·3	..	..	..	·6	29·3	..	..	..	..	·6
July	30·0	·6	..	..	..	..	28·3	..	..	..	·3	2·3
August	30·3	·3	..	..	..	·3	29·0	..	..	..	..	2·0
September..	26·6	·8	·3	..	..	2·0	22·6	·3	·2	..	4·0	2·6
October	23·5	2·6	3·4	..	..	1·4	19·0	·8	·6	..	4·4	5·2
November .	21·0	3·2	2·6	..	..	3·2	18·4	·6	·2	..	6·2	4·2
December ..	18·0	4·6	4·4	..	..	4·4	17·8	1·0	..	..	6·4	5·4

DISCUSSION.

Mr. A. BREWIN remarked that the paper would have been improved and rendered more interesting if further information had been given concerning the winds at Grand Canary, the references in the paper to this important factor in climate being very few, and in one place where it was stated that the wind for two months was continuously North to North-east, it was very doubtful which two months were referred to.

Mr. C. HARDING said that the Canary Islands being situated to the east and somewhat south of the area of high pressure in the Atlantic, the prevailing direction of the wind would be North and North-east. In the Tables accompanying the paper the small range of temperature was a very noticeable feature; this was particularly the case in 1889, and in January of that year the range between the absolute maximum, 67°·5, and the mean maximum, 65°·2, was only 2°·3. The minimum temperatures for the same month also exhibited a similarly small variation, the absolute being 55°·0, and the mean 57°·4. Possibly these figures were correct, although a person accustomed to examine and analyse meteorological data might reasonably suspect their accuracy, and be inclined to think that for that month, at any rate, the observations were probably incomplete. No doubt the information given in this paper was of considerable value, particularly from a medical point of view, as the Canary Islands were now coming into prominence as health resorts. From a meteorological standpoint objection must be taken to the manner in which the averages had been struck, some monthly means being based on five years' observations, some on four years', and one on three years'. Although a three-year average was a very poor one, it would be better to have all the means for a uniform period rather than for a varying number of years.

THE PRESIDENT (Mr. R. Inwards) said that no doubt the Canary Islands were coming to the front as health resorts for invalids, and any information concerning their climate was both interesting and valuable, but a friend who had resided at Las Palmas for a time told him that there was a great want of sanitation, and that with efficient drainage the town would be a perfect place of residence.

Mr. W. MARRIOTT said that Mrs. Stone, in her book *Tenerife and its Six Satellites*, gave some account of the climate of the Canary Islands, which agreed with the results of Dr. Taylor's observations. The French Bureau Central Météorologique also had a station at Las Palmas, the results of the observations from which were published in the *Annales*.

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Comparative Observations with two sets of Instruments at Ilfracombe, North Devon, during 1893.

By WILLIAM MARRIOTT, F.R.Met.Soc.

[Read February 21st, 1894.]

At the Meeting of the Society on June 15th, 1892, Mr. Bayard read a paper on "English Climatology, 1881-1890," in which he gave the results of the climatological observations for the 10 years at all the Society's stations. In the discussion which ensued some exception was taken to the Ilfracombe observations, as the thermometers were not mounted in a Stevenson screen; and it was thought that the high winter temperatures were not natural, but were really due the method of exposure.

The following account of the station was given in my Inspection Report[1] for 1880:—

"The instruments are exposed in a large screen, like a summer-house, the rain-gauge being on the top and having a pipe with a tap below. The stand is about 6 feet square, has large louvres half way down, then lattice work, is painted green, and has a slated pyramidal roof. It is placed over the shingle promenade of the Ilfracombe Hotel, and is 8 or 10 feet from the embankment, which rises about 16 feet. The exposure is quite open to the sea from the west to north. Capstone rock is about 200 yards distant on the north-north-east. On the borders and outskirts of the town, hills rise to the height of 500 to 800 feet. The whole of the soil is shale."

Although this screen was not of the regular pattern, I was of opinion that the temperature observations taken in it would be fairly comparable with those in a Stevenson screen.

On each of my visits to Ilfracombe I made inquiries as to the possibility of getting another station started in the town. On my last visit, in August 1892, I called on the Manager of the Ilfracombe Hotel, and pointed out to him the desirability of a Stevenson screen and a Snowdon rain gauge being obtained and placed over grass, so that no question could be raised as to quality of the observations, and that they might be strictly comparable with those from the other stations of the Society. I selected a site for the thermometer screen and rain gauge on the lawn to the east of the Hotel, and to the south of the old screen. The Directors subsequently carried out this recommendation; and the new instruments were put up at the beginning of October 1892.

The Stevenson screen is about 60 feet south of the old screen, and 96 feet from the wall of the Hotel; the rain gauge is about 90 feet from the old screen, and 90 feet from the Hotel.

[1] *Quarterly Journal*, Vol. VII. p. 109.

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As the observations from these two sets of instruments have now been carried on simultaneously by Mr. M. W. Tattam, the observer, for more than a year, I think the Fellows will be interested in having the results for the twelve months, January to December 1893. These are given in the accompanying Table.

RESULTS OF COMPARATIVE OBSERVATIONS WITH TWO SETS OF INSTRUMENTS AT ILFRACOMBE DURING 1893.

1893.	Temperature—Means.														
	9 a.m.			Minimum.			Maximum.			Range.			Mean.		
	Stevenson.	Old Screen.	Difference.	Stevenson.	Old Screen.	Difference.	Stevenson.	Old Screen.	Difference.	Stevenson.	Old Screen.	Difference.	Stevenson.	Old Screen.	Difference.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
January	41·4	40·8	—0·6	37·8	38·0	+0·2	43·8	43·9	+0·1	6·0	5·9	—0·1	40·8	41·0	+0·2
February	45·1	44·4	—0·7	40·9	41·1	+0·2	48·4	48·5	+0·1	7·5	7·4	—0·1	44·7	44·8	+0·1
March ..	48·7	48·3	—0·4	42·8	43·1	+0·3	54·0	54·0	0·0	11·2	10·9	—0·3	48·4	48·5	+0·1
April	53·0	52·7	—0·3	46·6	47·0	+0·4	60·1	60·5	+0·4	13·5	13·5	0·0	53·3	53·8	+0·5
May	56·8	56·7	—0·1	51·6	52·0	+0·4	61·7	62·1	+0·4	10·1	10·1	0·0	56·7	57·0	+0·3
June	61·3	61·0	—0·3	55·2	55·6	+0·4	65·7	66·1	+0·4	10·5	10·5	0·0	60·4	60·9	+0·5
July	62·8	62·6	—0·2	58·2	58·5	+0·3	66·2	66·4	+0·2	8·0	7·9	—0·1	62·2	62·4	+0·2
August ..	65·0	64·6	—0·4	59·8	60·1	+0·3	69·1	69·3	+0·2	9·3	9·2	—0·1	64·5	64·7	+0·2
September	59·9	59·5	—0·4	54·8	55·4	+0·6	62·6	62·9	+0·3	7·8	7·5	—0·3	58·7	59·2	+0·5
October ..	55·3	55·0	—0·3	50·5	50·9	+0·4	58·3	58·4	+0·1	7·8	7·5	—0·3	54·4	54·6	+0·2
November	46·7	46·5	—0·2	42·7	43·1	+0·4	49·7	49·9	+0·2	7·0	6·8	—0·2	46·2	46·5	+0·3
December	46·7	46·3	—0·4	41·6	42·0	+0·4	49·6	49·9	+0·3	8·0	7·9	—0·1	45·6	46·0	+0·4
Year ..	53·6	53·2	—0·4	48·5	48·9	+0·4	57·4	57·7	+0·3	8·9	8·8	—0·1	53·0	53·3	+0·3

1893.	Temperature—Extremes.									Relative Humidity.			Rain.		
	Minimum.			Maximum.			Range.								
	Stevenson.	Old Screen.	Difference.	Stevenson.	Old Screen.	Difference.	Stevenson.	Old Screen.	Difference.	Stevenson.	Old Screen.	Difference.	Snowdon, 1 foot.	Old Gauge, 9 feet.	Difference per cent.
	°	°	°	°	°	°	°	°	°	%	%	%	Ins.	Ins.	%
January	28·4	28·3	—0·1	53·5	53·6	+0·1	25·1	25·3	+0·2	85	87	+2	2·57	1·99	—23
February ..	32·5	33·3	+0·8	55·9	56·0	+0·1	23·4	22·7	—0·7	85	87	+2	5·62	4·44	—21
March	37·5	35·7	—1·8	63·8	64·0	+0·2	26·3	28·3	+2·0	85	85	0	·52	·41	—21
April	35·7	36·1	+0·4	78·9	78·0	—0·9	43·2	41·9	—1·3	78	81	+3	·22	·17	—23
May	44·9	45·3	+0·4	74·7	75·6	+0·9	29·8	30·3	+0·5	85	84	—1	2·75	2·51	— 9
June	49·9	50·5	+0·6	79·7	80·0	+0·3	29·8	29·5	—0·3	85	86	+1	1·10	·93	—15
July	52·4	52·8	+0·4	78·9	79·0	+0·1	26·5	26·2	—0·3	86	86	0	5·15	4·40	—15
August.....	52·9	54·3	+1·4	82·9	83·2	+0·3	30·0	28·9	—1·1	85	85	0	2·13	1·75	—18
September ..	46·9	47·9	+1·0	72·9	73·2	+0·3	26·0	25·3	—0·7	80	82	+2	3·01	2·37	—21
October	36·9	38·3	+1·4	65·3	65·6	+0·3	28·4	27·3	—1·1	83	82	—1	5·14	4·02	—22
November ..	35·4	36·3	+0·9	57·8	58·0	+0·2	22·4	21·7	—0·7	85	85	0	2·63	2·00	—24
December ..	28·9	29·9	+1·0	55·2	55·2	0·0	26·3	25·3	—1·0	86	85	—1	6·27	5·09	—19
Year	..	..	+0·5	..	..	+0·2	..	..	—0·3	84	85	+1	37·11	30·08	—19

At 9 a.m. the temperature in the Stevenson screen is on the average 0°·4 higher than in the old screen. With regard to the mean minimum and maximum, the old screen records a higher temperature than the Stevenson

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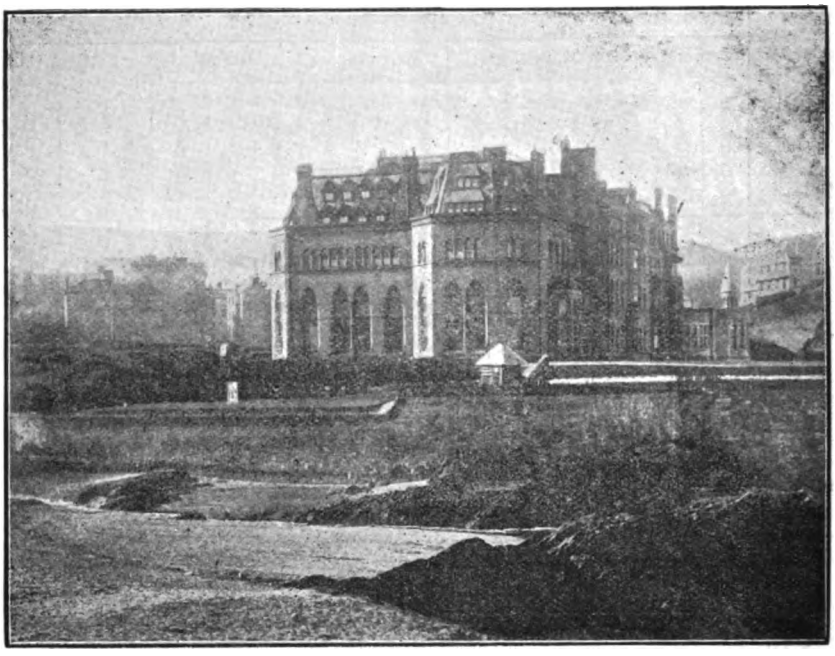
screen, the excess for the minimum being 0°·4, and for the maximum 0°·8. The mean temperature, as deduced from the observations made in the old screen, is 0°·3 higher than that from those made in the Stevenson screen. The extremes show practically the same result; the mean of the absolute minima being 0°·5, and the mean of the absolute maxima being 0°·2, higher in the old screen than in the Stevenson screen.



The relative humidity does not show much variation, the mean for the year being 1 per cent. greater in the old screen than in the Stevenson screen.

The difference in the amounts of rain collected by the two gauges is somewhat considerable, as was to be expected, the old gauge being 9 feet above the ground and placed on the top of the thermometer screen, while the new gauge is of the Snowdon pattern, the rim being 1 foot above the ground. The total rainfall collected by the Snowdon gauge during the year was 37·11 ins., while the old gauge collected only 30·08 ins., the difference being 19 per cent.

The results from the new set of instruments have been printed in the *Meteorological Record* since January 1893 in place of those from the old instruments.

DISCUSSION.

Mr. R. J. LECKY sent the following note, which was read by the Secretary:—"Were I with you on Wednesday I should probably make a remark or two on Stevenson's clever and valuable screen, now, I presume, in almost universal use, so that if there be any fault in its construction occasioning an error it becomes a "constant" in any comparisons of temperature with other observations.

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What I fear in these screens is a want of proper ventilation, and that in extremely hot sultry weather, especially where they are exposed to the full sun, they become a species of oven and give too high a temperature (I do not so much fear a *vice versa* effect in winter) *e.g.* my Six thermometer, in a fairly sheltered open air position, where it agrees well with others, gave 87° as the highest last summer, while 93° was reported from, I presume, a Stevenson screen. It would be interesting if some meteorologists would make a series of observations with a well defended open air thermometer and that in a screen; it would of course require a fairly long series, so as to eliminate extra disturbances. As to the ventilation I allude to, I have always thought that the louvring was overdone in being doubled and too small a distance between the laths; as also that the louvring ought to be vertical instead of horizontal as at present, in fact on the principle of "Day's" wind guard for chimney tops (made as in his original patent of 40 or 50 years ago, not as scamped by present makers), which would not hamper the free ventilation as the present double confined louvring does.

Mr. C. LAWRENCE said that, being a frequent visitor to Ilfracombe, he had, in November last, made an inspection of the screens in which the thermometers are placed there, and had also interviewed Mr. M. W. Tattam, who takes the records with the approval of the Society, and who was evidently perfectly well qualified to make observations, carrying out the work in a conscientious manner. The Society had done a good thing in establishing a Stevenson screen and making comparative observations between the temperatures in that screen and those in the old form of shelter, for the result clearly showed that the temperature of Ilfracombe as registered in the old screen was practically correct, and that the fact of its having the highest mean temperature in the United Kingdom was well established.

Mr. E. MAWLEY, referring to Mr. Lecky's letter, said that no better refutation of the idea that a Stevenson screen was likely to become heated up "like an oven," owing to its want of sufficient ventilation, could be given than the photograph of the Ilfracombe screen, which showed that whatever the other defects of that screen might be it was at all events freely ventilated on all sides; and yet on turning to the Table of comparative observations it would be seen that on the hottest days of last year the Stevenson screen comes out as rather the cooler of the two. He had made various experiments with the Stevenson screen in order to determine its suitability for the exposure of thermometers, having compared the records of one of these screens, sheltered at the top and sides with canvas and placed in full sunshine with an ordinarily exposed screen also in sunshine, and also a screen placed in the shade of a tree with one fully exposed to the sun's rays, the results of these various tests showing that the differences between ordinary exposure and shaded exposure were but slight. He regarded the Stevenson screen, all things considered, as the best form of exposure for thermometers; but he was glad that the records of the old screen at Ilfracombe were found to approximate so closely to those of the Stevenson screen, as if it had been otherwise a long series of observations would have been spoiled.

Mr. F. C. BAYARD said that in the discussion on his paper on "English Climatology, 1881-90," read at the meeting of the Society on June 15th, 1892, Mr. Symons had expressed considerable doubt concerning the accuracy of the temperatures at Ilfracombe, believing that the peculiar construction of the screen caused too high a temperature to be recorded. It was very satisfactory to find that such was not the case, and that the exceptional warmth of Ilfracombe was entirely due to its sheltered situation, so that it was one of the warmest places in the British Isles, excepting the Channel Islands.

Mr. C. HARDING said that the large form of screen at Ilfracombe appeared to bear some resemblance to the thermometer shelter used in India, and it was very gratifying, although somewhat surprising, that the results from the Stevenson screen agreed so well with those from the old screen. Much variation between the mean values in the different screens was hardly to be expected, but the extreme temperatures also exhibited very small differences. He had on some occasions noticed as much as a difference of 1° between two similar thermometers in a Stevenson screen, and in the morning had seen the maximum thermometer indicating a lower temperature than the dry bulb; the difference being apparently due to the sun shining on the side of the screen to which the dry bulb was in closest proximity.

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Mr. R. H. Scott drew attention to the form of thermometer shelter used at the Ordnance Survey Office, Dublin, from 1842 to 1879, when a Stevenson screen was supplied by the Meteorological Office. It was described and illustrated in an Ordnance Survey publication entitled *Meteorological Observations taken during the years* 1829 *to* 1852 *at the Ordnance Survey Office, Phœnix Park, Dublin.* The description was as follows :—"The Observatory.....is an octagonal wooden structure, with a dome shaped roof; the length of the exterior side is 6 feet, and the height above the ground to the springing of the ellipsoidal dome 7 feet 4 inches. Each side consists of an external and internal frame, of fixed louvred work, having a space of 6 inches between the frames. Alternate sides are made to open like folding doors, but it was not usual to open any one of the sides except occasionally for the purpose of admitting more light at the time of reading."

The President (Mr. R. Inwards) said that it was satisfactory to find that the temperature observations agreed so closely despite the difference in the construction and size of the two screens, 0°·5 being the extreme limit of error. The variation in the rainfall was, however, considerable, and he hoped that some satisfactory explanation would be given of the divergence of 19 % which had been found to exist between the two gauges, as the comparatively slight difference in their situation did not appear to be sufficient to account for so large an error as 19 %. Regarding Mr. Lecky's remarks and suggestions, it did not appear that vertical louvring possessed any advantages over the form of louvres as now constructed. Prof. Tyndall's idea of the manner in which a thermometer should be exposed was to suspend a spirit thermometer in the open air on a cord or string stretched between two posts fixed in the ground.

Mr. W. Marriott said that Dr. Buchan had informed him that a somewhat similar screen had been in use for many years at Braemar. A short time ago a Stevenson screen was set up beside it, and comparative observations made in the two screens, when results were obtained which were similar to those at Ilfracombe.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

January 17th, 1894.

Ordinary Meeting.

C. Theodore Williams, M.A., M.D., President, in the Chair.

John Alfred Fox, L.R.C.P., M.R.C.S., Tregea House, Penzance ;
Frederic Merrifield, 24 Vernon Terrace, Brighton ; and
Thomas James Scott, Edlestone House, Prestatyn, Rhyl,
were balloted for and duly elected Fellows of the Society.

Robert Lewis John Ellery, F.R.S., Government Observatory, Melbourne ; and
Dr. Maurits Snellen, Royal Meteorological Institute of the Netherlands, Utrecht, were balloted for and duly elected Honorary Members of the Society.

The Secretary stated that the Council had requested the following letter from the President to be read to the Society :—

"2 Upper Brook Street, W.
"January 7th, 1894.

"Gentlemen,

"As I shall shortly retire from the Presidency of the Royal Meteorological Society, the tenure of which office for two years I shall always regard as

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a high honour conferred on me by a learned and scientific Society, I wish to leave behind some memorial of my pleasant term of office, and after considering the matter carefully, and consulting with some of our colleagues, I have decided to present the sum of £100 to form the nucleus of a Research Fund, to defray the expenses of such experiments and observations in meteorology as the Council may from time to time think fit to investigate.

"I would instance, as the kind of work contemplated, the Wind Force experiments, and the observations taken on the Boston Church Tower.

"In the event of no grants being made for a while from the Fund, the money is to be invested and the interest allowed to accumulate to augment the sum available for future grants.

"Hoping that the institution of such a fund will forward the progress of the Society, of which there is no more ardent admirer than myself, thanking you warmly for the support and indulgence you have extended to me during my term of office, and with all good wishes for you collectively and personally,

"I remain,
"Yours faithfully,
"C. THEODORE WILLIAMS."

"The Council of the Royal Meteorological Society."

MR. R. H. CURTIS exhibited and described some lantern slides showing the wind records obtained from the Dines' Anemometer at Westminster, and from the Bridled Anemometer at Holyhead, during the November gale. (p. 43.)

January 17th, 1894.

Annual General Meeting.

C. THEODORE WILLIAMS, M.A., M.D., President, in the Chair.

MR. F. B. EDMONDS and MR. H. HARRIES were appointed Scrutineers of the Ballot for Officers and Council.

MR. F. C. BAYARD read the Report of Council and the Balance Sheet for the past year (p. 92).

It was proposed by the PRESIDENT, seconded by Mr. F. C. BAYARD, and resolved:—"That the Report of the Council be received and adopted, and printed in the *Quarterly Journal*."

It was proposed by Mr. A. BREWIN, seconded by Mr. W. M. BEAUFORT, and resolved:—"That the thanks of the Society be given to the Officers and other Members of Council for their services during the past year."

It was proposed by Mr. F. J. BRODIE, seconded by Capt. W. F. CABORNE, and resolved:—"That the thanks of the Society be given to the Standing Committees and to the Auditors, and that the Committees be requested to continue their duties till the next Council Meeting."

It was proposed by the Hon. F. A. R. RUSSELL, seconded by Dr. R. BARNES, and resolved:—"That the best thanks of the Royal Meteorological Society be communicated to the President and Council of the Institution of Civil Engineers for having granted the Society free permission to hold its Meetings in the rooms of the Institution."

The PRESIDENT then delivered an Address on "The Climate of Southern California" (p. 81).

It was proposed by Mr. BALDWIN LATHAM, seconded by Sir RICHARD QUAIN, and resolved:—That the thanks of the Society be given to Dr. C. THEODORE WILLIAMS for his services as President during the past year and for his generous gifts, and also for his Address, and that he be requested to allow that to be printed in the *Quarterly Journal*."

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The Scrutineers declared the following gentlemen to be Officers and Council for the ensuing year :—

President.

RICHARD INWARDS, F.R.A.S.

Vice-Presidents.

ROBERT BARNES, M.D., F.R.C.P.
HON. FRANCIS ALBERT ROLLO RUSSELL, M.A.
STEPHEN WILLIAM SILVER, F.R.G.S.
CHARLES THEODORE WILLIAMS, M.A., M.D., F.R.C.P.

Treasurer.

HENRY PERIGAL, F.R.A.S., F.R.M.S.

Secretaries.

FRANCIS CAMPBELL BAYARD, LL.M.
GEORGE JAMES SYMONS, F.R.S.

Foreign Secretary.

ROBERT HENRY SCOTT, M.A., F.R.S.

Council.

ROBERT WILLIAM PEREGRINE BIRCH, M.Inst.C.E., F.G.S.
GEORGE CHATTERTON, M.A., M.Inst.C.E.
WILLIAM HENRY DINES, B.A.
WILLIAM ELLIS, F.R.S., F.R.A.S.
CHARLES HARDING.
BALDWIN LATHAM, M.Inst.C.E., F.G.S.
ADMIRAL JOHN PEARSE MACLEAR, R.N., F.R.G.S.
WILLIAM MARCET, M.D., F.R.S., F.C.S.
EDWARD MAWLEY, F.R.H.S.
HENRY SOUTHALL, F.R.H.S.
WILLIAM BLOMEFIELD TRIPP, M.Inst.C.E.
CAPT. DAVID WILSON-BARKER, F.R.G.S.

Dr. C. T. WILLIAMS having left the Chair, it was taken by Mr. R. INWARDS, the newly elected President, who thanked the Fellows for the honour they had conferred upon him in electing him to that office.

February 21st, 1894.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

RICHARD MANLIFFE BARRINGTON, M.A., LL.B., F.L.S., Fassaroe, Bray, Co. Wicklow ;
C. G. LUMLEY CATOR, 7 Southwick Place, Gloucester Square, W. ; and
HENRY OWEN, F.R.G.S., 26 Albion Street, Hyde Park, W.,
were balloted for and duly elected Fellows of the Society.

The following Papers were read :—

"REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1893." By EDWARD MAWLEY, F.R.Met.Soc. (p. 125.)

"TEMPERATURE, RAINFALL, AND SUNSHINE AT LAS PALMAS, GRAND CANARY." By J. CLEASBY TAYLOR, M.D. (p. 154.)

"COMPARATIVE OBSERVATIONS WITH TWO SETS OF INSTRUMENTS AT ILFRACOMBE DURING 1893." By WILLIAM MARRIOTT, F.R.Met.Soc. (p. 164.)

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CORRESPONDENCE AND NOTES.

The late Arthur Hill Hassall, M.D.—Dr. Hassall's work in Natural History, Hygiene, on Food, in Physiology and Medicine was so striking that his contributions to Meteorology have hardly received the recognition they deserve. His work in this direction was not merely devoted to barren observation; but he applied it to the practical objects of the preservation of health and the cure of disease. It would be difficult to find in the history of Medicine a more valuable example of the application of meteorological science than that supplied by the National Hospital for Consumption at Ventnor, founded by him. The principle of isolation of the patients, thus securing to each air free from mutual contamination, and so avoiding "hospital air," was here first put into practice. The next point was that each patient's bed-room should face south. All the other arrangements were made to harmonise with this leading idea. Another illustration of Dr. Hassall's attention to meteorology—that is, of making air the vehicle of healing agents—was his advocacy of the treatment of consumption by inhalation. Space will not admit of dwelling further upon this topic. But we cannot close this brief notice without recording one—the last proof of the keen devotion to the study of nature which animated him throughout.

He had kept up a systematic observation of the Meteorological phenomena at San Remo for the last twelve years. This fact, and the knowledge that he was ever ready to enter upon new fields of investigation, induced me to seek his aid in carrying out the proposition I had started in the Royal Meteorological Society, to observe the changes in the constitution and properties of the air under different conditions. I wrote to him last February asking him to note the proportion of salt in the rain-water falling near the sea; that we might have a standard of comparison with rain coming from other seas besides the Mediterranean and further inland. He immediately set to work. In a letter dated February 21st, he says: "No rain fell for some days after your letter. I have now, however, obtained two separate samples, and have determined the chloride of ammonium in each case. The amount in each case is nearly identical, namely, 0·040 per litre, equal in round numbers to about a grain. The smallness of the quantity is perhaps to be explained by the fact that there was no wind from the sea at the time." On March 27th, he writes again, "In my own view of my case I think that there is little hope of contemporary recovery. With regard to salt in the air over the sea, it is astonishing, considering the winds, how little evidence there is of the presence of salt. One never feels it on one's lips; it never accumulates on the window panes; and it is only now and again, owing to the absence of sea-weed, that you ever even get a sniff of the sea. The only evidence of saltness is that steel articles after a good deal of exposure become somewhat rusty."

So that to the last he sought to unravel the arcana of Nature. On April 9th he died. No man had a better claim to the epitaph, "*Non omnis moriar.*"—ROBERT BARNES.

Waterspout in Somerset, April 26th, 1894.—A severe thunderstorm passed over the neighbourhood of Chew Stoke about 8 a.m. on Thursday, April 26th. In the height of the storm a waterspout was seen forming on Black Down, a high point on the Mendips, just above the village of Blagdon. The storm passed over Breach Hill in a north-easterly direction, accompanied by a cyclonic disturbance, which, however, only embraced a narrow path. On reaching Chew Stoke the tiles on a house were dislodged, causing great alarm to the inmates. At Chew Magna, which was in the path of the storm, the roofs of some carpenters' workshops were much damaged.

Atmospheric Electricity.—Observations have lately been made from the Eiffel Tower to ascertain the voltage variations at different heights and upon different days. The diurnal variations are the more consistent the greater the height; there is a minimum voltage in the morning and a maximum in the evening. The morning readings agree, as to time of minimum, whether taken upon the top of the tower or on the level; the evening maximum occurs one hour sooner upon the tower than upon the level. The mean potential was 3,000 volts, frequently rising above 10,000.—*Electrical Review.*

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Lightning and Trees.—M. Dimitrie has found that different kinds of wood have very different conductivities for the sparks of a Holtz machine. Oak was easily pierced, but beech was highly resisting. The quantity of water present was not so important as the amount of oil. Woods containing starch, and but little oil, like oak and poplar, have much less resistance to sparking than those containing oil, like the beech. Pine, which contains oil in winter much more than in summer, is comparable with oak in resistance to sparks. When the oils are extracted by ether, these woods are as easily pierced as the starch varieties. Those containing starch are less easily pierced when living than when dead; the bark and foliage in all the trees are poor conductors. The conclusions accord with the observations that in a certain case 159 oaks were struck by lightning, as against 21 beeches and 59 pines. The danger of being struck, taking beech as the standard, is 5 for Norway pine, 33 for pine, and 48 for oak.—*Electrical Review.*

Tornado at Novska, May 31st, 1892.—Mons. A. Mohorovicic has communicated an interesting paper on this tornado to the South Sclavish Academy of Science and Art. Novska is a town on the Save about one third of the way between Agram and Belgrade, and just on the southern edge of the hills lying between the Save and the Drave. On the afternoon of May 31st, the four o'clock train going eastwards was caught by the whirlwind when it had got about 150 yards from the station. The last four carriages were thrown off in a south-west direction, the front of the train in a north-east direction. The middle carriages were uninjured. One carriage, weighing 13 tons with three passengers, was apparently carried over the hedge and the telegraph wires for a distance of 30 yards. The hedge and wires were uninjured. The passengers' accounts of their experiences are contradictory, and small wonder! The guard was thrown out at an early stage of the performance. No one was killed, but a great deal of damage to buildings was reported. One girl, looking after a flock of geese, was caught up by the wind and came to herself after her flight with only a scratch on the hand. A bystander saw her in the air, and her long hair-pins were found 300 yards from her final stopping place. A map giving the directions of the different groups of fallen trees in the adjacent forests shows that the circulation was cyclonic. The greatest force was apparently exerted on the tail of the train.

Large Hailstones at Sea.—The following is an extract from the Meteorological Log No. 9,156, kept on board the S.S. *Anglian*, by Captain F. J. Mosley:—

"October 8th, 1893. Position at noon, lat. 47°3′ N. long. 6°22′ W., 8.30 a.m. Heavy thunderstorm accompanied by hail of the size of walnuts. Wind fell light, continued veering and backing between West and South-south-east, with hard rain squalls at short intervals for two hours, then steadied at South-south-west. The hailstones in this shower were of phenomenal size, many being an inch in diameter. Two actually measured were 1¼ inches in diameter."

Monthly Weather Report for Russia.—With January 1893, the Russian Meteorological Office commenced the issue of a Monthly Weather Report for agricultural purposes, somewhat corresponding to our own *Weekly Weather Report*. The Russian paper does not deal with accumulated temperature at all, and treats of decades, not of calendar weeks. It gives, however, barometrical data which are entirely absent from the British report. The stations for which data are furnished are the Telegraphic Reporting Stations of the Russian and Finnish system, and numbered 73 in 1893. The barometer is entered without any comparison with standard means. The temperature is given for the decades and the month with difference from the mean in each case. Absolute max. and min. for the month are given for such stations as observe these phenomena or either of them. The other information contained in the table on the first page relates to relative humidity, amount of cloud, and wind frequency (8 points). Rain, with difference from averages for decades and months, is given for 312 stations, and also the number of days of snow covering, and the Report is accompanied by a map.

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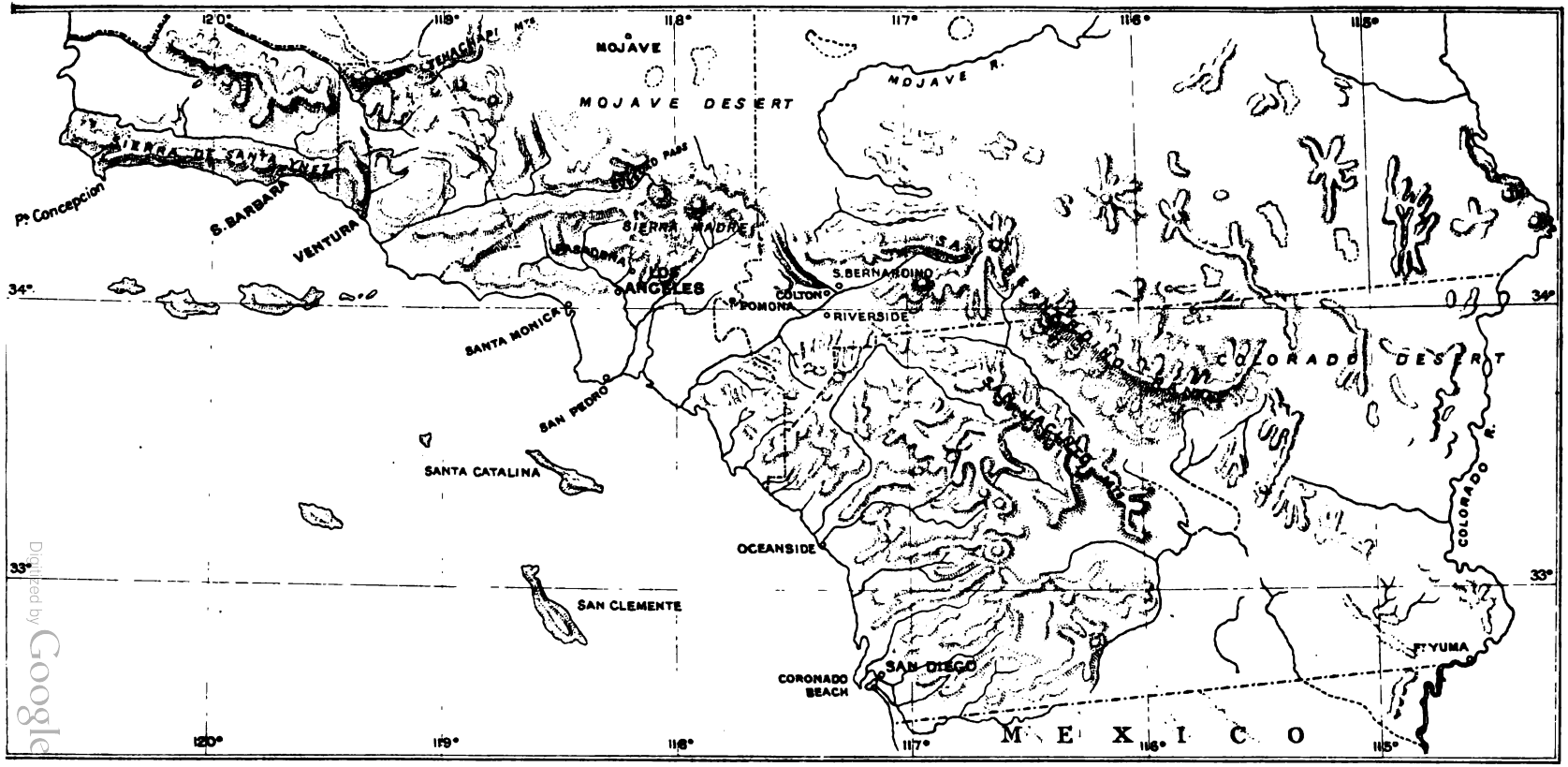
SOUTHERN CALIFORNIA.



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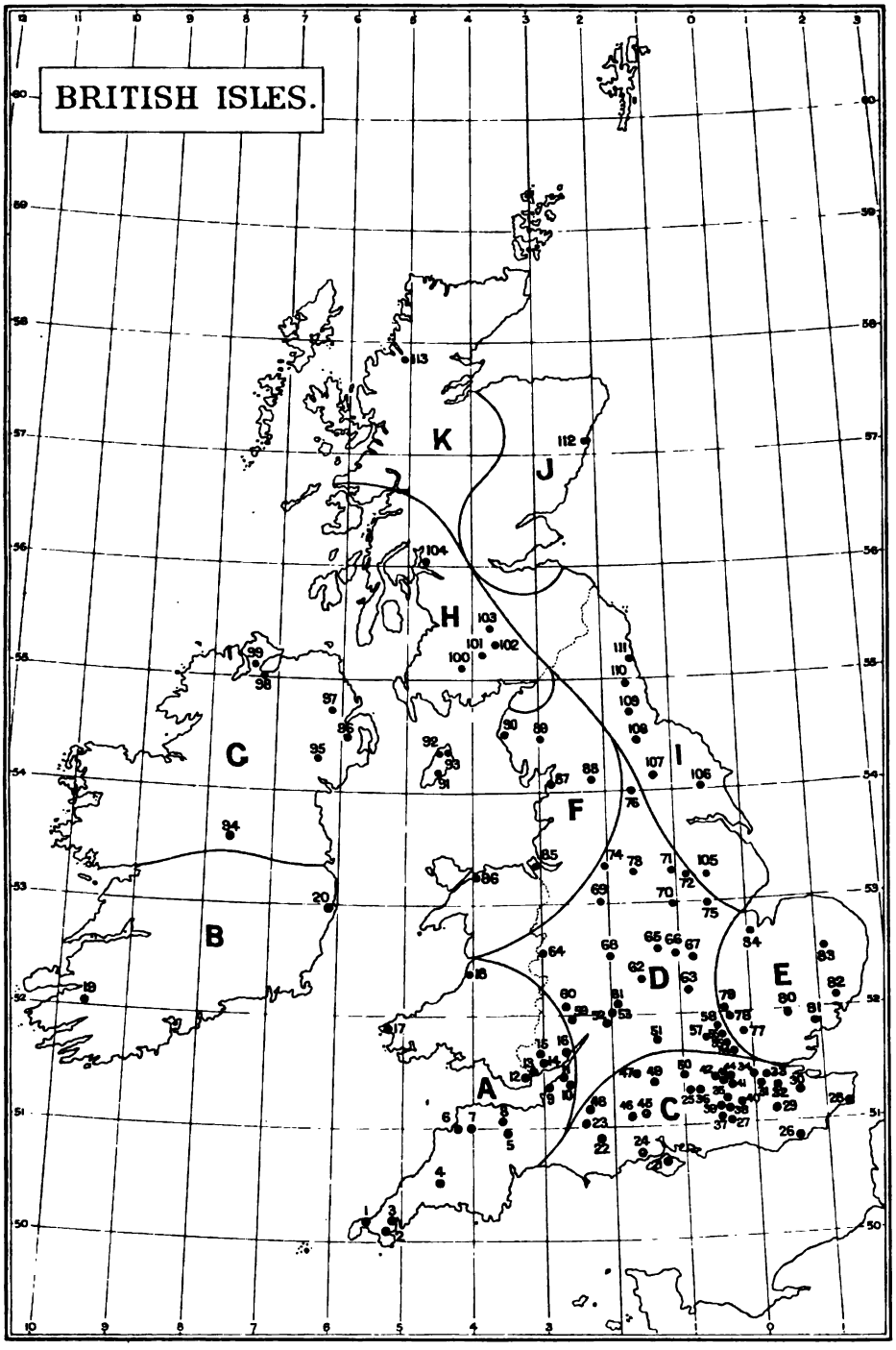
MAP SHOWING POSITION OF THE PHENOLOGICAL STATIONS, 1893.



For the Names of the Stations see List of Observers, Page 130.

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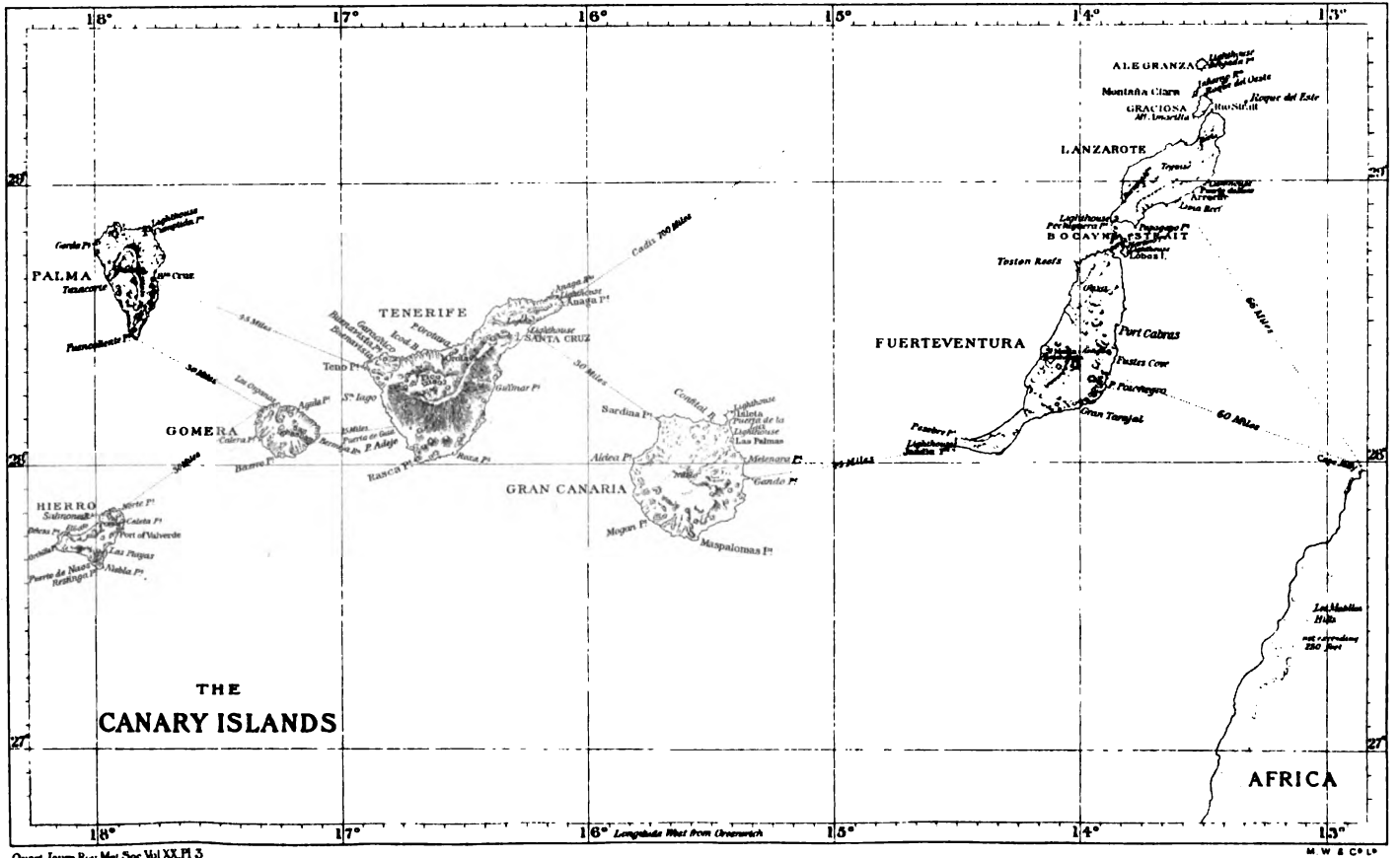

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SEPARATE COPIES OF PAPERS.

Separate copies of Papers appearing in the *Quarterly Journal* are kept on sale, at the Office of the Society, at a price of Sixpence per Half Sheet, or portion thereof. The following are some of those on sale:—

	s.	d.
ABERCROMBY, HON. RALPH, AND HILDEBRANDSSON, DR. H. H.—Suggestions for an International Nomenclature of Clouds. (Plate.)	2	0
ABERCROMBY, HON. RALPH, AND MARRIOTT, W.—Popular Weather Prognostics. (Five Illustrations.)	1	0
BAYARD, F. C.—English Climatology, 1881-1890. (Plate.)	1	6
BRODIE, F. J.—The Great Drought of 1893, and its attendant Meteorological Phenomena. (Four Illustrations)	2	0
DINES, W. H., B.A.—Anemometer Comparisons. (Plate and Eight Illustrations.)	2	0
ELLIS, W.—Relation between the duration of Sunshine, the amount of Cloud, and the height of the Barometer	0	6
ELLIS, W.—The Mean Temperature of the Air on each day of the year at the Royal Observatory, Greenwich, on the average of the fifty years 1841 to 1890. (Illustration.)	0	6
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OF THE

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EDITED BY A

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JULY 1894.

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Offices:—22 GREAT GEORGE STREET, WESTMINSTER, S.W.

SESSION 1894-5.

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January 16, 1895.

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LUKE HOWARD, F.R.S.

Born 1772; died 1864.

(From a Drawing by Bedford about 1843.)

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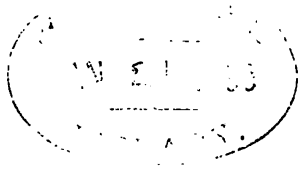

QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY.

VOL. XX. JULY 1894. No. 91.

ON THE RELATION BETWEEN THE MEAN QUARTERLY TEMPERATURE AND THE DEATH RATE.

BY W. H. DINES, B.A., F.R.Met.Soc.

[Received February 21st.—Read March 21st, 1894.]

HAVING been struck by the continuously high weekly death rate during the last, remarkably hot, summer, I was led, as a matter of curiosity, to tabulate the returns for preceding years, to see whether the occurrence was merely a coincidence or a general rule.

The *Quarterly Returns* of the Registrar-General for the whole of England, published since 1862, have been taken, and the number of deaths each quarter expressed as a departure per thousand, *plus* or *minus*, from that particular quarter's average; the value so obtained being placed side by side with the corresponding departure of the temperature from its mean value.

It is well known that down to about 1888 a steady decrease of the death rate occurred, a decrease which has now unfortunately ceased. It is obvious that it would not be fair to compare the rate at either end of the period with

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the mean for the whole, hence the 32 years have been divided into three nearly equal parts and the rate compared with the average of the part in which it occurred.

The Registrar General's returns relate to the civil quarter (January-March, &c.), but the temperature has been taken for the seasonal quarter (December-February, &c.). This seemed to be the more satisfactory course, for the cause must precede the effect. Also the connection between heat and diarrhœa is perfectly well known, but the time of the highest death rate from diarrhœa comes some three weeks or so later than the time of highest temperature. It may be added that had the civil instead of the seasonal quarter been taken the results would have been substantially the same.

The mean temperature is that of Greenwich. A more central station would have been better, but for so long a period as three months, the Greenwich temperature, considered simply as a departure from the mean, must be fairly representative of that of England.

TABLE SHOWING THE DEPARTURES FROM THE AVERAGE OF THE QUARTERLY DEATH RATE AND OF THE QUARTERLY MEAN TEMPERATURE.

Year.	Winter.		Spring.		Summer.		Autumn.	
	Death Rate.	Temp.	Death Rate.	Temp.	Death Rate.	Temp.	Death Rate.	Temp.
		°		°		°		°
1862	— ·9	+1·1	— ·6	+1·9	—3·1	—2·5	·0	— ·4
1863	·0	+3·2	+1·2	+1·2	+ ·6	— ·5	— ·2	+ ·1
1864	+2·2	— ·7	+ ·7	+ ·7	+ ·3	—1·2	+1·1	— ·4
1865	+1·2	—2·2	+ ·2	+1·2	+ ·2	+ ·5	+ ·4	+3·0
1866	+1·2	+2·5	+2·4	— ·9	+ ·6	— ·4	— ·6	+ ·5
1867	·0	+1·3	— ·9	— ·4	—1·2	—1·0	—1·1	—1·0
1868	—3·3	— ·1	—1·6	+2·7	+2·6	+3·6	— ·6	— ·2
1869	— ·8	+4·8	— ·3	—1·0	— ·6	— ·6	+ ·5	+ ·1
1870	+ ·8	—1·8	— ·2	+ ·2	+ ·9	+1·7	— ·1	—1·2
1871	— ·5	—2·9	— ·5	+1·1	·0	— ·4	+1·0	—2·1
1872	+ ·1	+2·5	+ ·4	+ ·8	+1·8	+ ·9	— ·7	·0
1873	— ·5	+ ·8	— ·3	— ·9	+ ·2	+1·2	+ ·6	—1·3
1874	— ·1	+1·0	+ ·3	+1·0	+1·6	+ ·1	+2·8	+ ·3
1875	+4·0	—2·1	+1·4	+ ·1	+ ·9	— ·5	+ ·8	— ·1
1876	·0	+ ·3	+ ·2	—1·2	+ ·3	+1·9	—1·1	+ ·7
1877	—1·2	+4·1	+ ·7	— 2·1	—1·6	+0·5	— ·8	—1·2
1878	— ·8	+1·8	+ ·1	+1·4	+1·4	+1·2	+1·6	— ·9
1879	+1·5	—4·7	+ ·3	—2·8	—2·9	—2·5	+ ·1	—2·3
1880	— ·7	—3·2	—1·0	+ ·9	+1·1	·0	—1·4	— ·8
1881	—1·8	—1·5	+2·0	+ ·4	—2·5	+ ·3	—2·3	— ·4
1882	·0	+1·4	— ·1	+2·4	+ ·6	—2·0	+ ·9	— ·7
1883	+ ·8	+2·0	+1·0	—1·8	— ·3	— ·5	+ ·1	+ ·1
1884	—1·9	+2·5	— ·1	+ ·9	+2·7	+1·8	+ ·8	·0
1885	+ ·4	+1·2	+ ·3	—1·1	— ·5	— ·2	— ·5	—2·0
1886	+1·5	—3·1	— ·9	— ·7	+ ·9	+ ·1	— ·5	+1·8
1887	— ·7	—2·3	— ·7	—3·3	+ ·7	+2·5	— ·1	—3·6
1888	— ·2	—2·3	—1·4	—2·3	—2·0	—2·4	—1·1	— ·6
1889	—1·7	—1·0	—1·7	+ ·5	— ·3	·0	+ ·9	— ·6
1890	+1·7	— ·5	—1·3	+ ·4	— ·3	—1·8	+ ·9	+ ·7
1891	+ ·4	—5·2	+4·5	—2·2	—1·3	—1·0	+ ·1	+ ·8
1892	+2·3	— ·5	—1·2	·0	—1·6	—1·0	—1·8	—1·2
1893	—1·9	—1·6	+1·3	+4·6	+2·0	+2·7	+0·7	— ·1

In the winter quarter there seems to be no fixed rule, though it has been supposed that a cold winter is unhealthy and a warm winter healthy. Like

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signs occur together, that is a + with a +, or a − with a −, twelve times, and unlike signs sixteen times, the remaining four being instances in which an exact average value occurs, which cannot be called either *plus* or *minus*. Thus out of 28 winters we have 12 exceptions to the supposed rule. The exceptionally mild winters of 1866 and 1883 were unhealthy, and those of 1868 and 1872 had an average death rate. The exceptionally cold winters of 1881 and 1893 were exceptionally healthy, and those of 1880, 1887, 1888, and 1891 had a nearly average rate. With the exception of 1813-14, 1891 seems to have been the coldest winter of this century, and the fact that such a winter had an average death rate proves that prolonged cold is not necessarily prejudicial to health. This is the more remarkable, for 1891 was notorious for the number of its fogs.

Marked instances occur in 1865, 1875, 1877, 1879, 1884, and 1886, but 1889 gives the case of a healthy winter being coincident with a rather cold one, and 1892 of an exceptionally unhealthy winter occurring with a nearly average temperature. Thus in 32 years we have six well-marked examples and five well-marked exceptions, and I think the figures justify our stating that there is no definite relation. They do, however, show that the old proverb that "a green yuletide makes a fat churchyard" is not true.

In the summer quarter there is a marked relation between the temperature and the death rate. A hot summer is always unhealthy and a cool summer healthy. We have 22 like signs occurring together and 7 unlike.

The two summers notorious for cold, viz. 1862 and 1879, are the two healthiest summers in the list. The hottest summer, 1868, is also the most unhealthy but one. Marked instances of the rule occur in 1863, 1867, 1868, 1878, 1879, 1884, 1888, 1891, 1892, and 1893, each of these being an exceptional summer accompanied by an exceptional death rate.

Every hot summer in the list has a death rate exceeding the average, and every cold summer, excepting 1882, has a death rate below the average. There are no actual exceptions to the rule, but two partial ones, viz. the healthy summer 1881 occurring with an average temperature, and the cold summer of 1882 occurring with a + death rate.

The excessive mortality in a hot summer is partly caused by the deaths by diarrhœa of children under 5 years of age, but even if all returns from this disease were excluded the rule given above would hold.

It does not seem possible to deduce from the figures even the semblance of any relation between the two quantities for the spring and autumn quarters.

The conclusions reached so far being contrary to the general opinion on the subject, it may be well to examine the figures more in detail.

In the winter quarter there are only two years in which neither quantity departs by less than 1·0 from the average. There are eleven years in which one quantity is within ·5 of the average and the other more than 1·0 away from it. There are 19 years in which both quantities differ from the average by more than ·5. Out of these 19 years 12 are favourable to the idea that a cold winter is unhealthy, and 7 are opposed to it.

In the summer quarter the corresponding numbers are 10, 8, and 17.

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Out of the 15, 14 show that a cold summer is healthy and a hot one unhealthy and 1 only is unfavourable to this view.

These results are very plainly shown in figs. 1 and 2, in which the quarters have been arranged in descending order of temperature. A distance of one-tenth of an inch above the line indicates a temperature of 1° above the average, and also a death rate of 1 per annum per thousand above the mean for the corresponding quarter.

A glance at the winter diagram shows the absence of any relation between the temperature and the death rate. The mean for all the quarters in which the temperature was 1° or more above the average, is only 0·24 below, the quarters in which the temperature differed by less than 1° from the average, *i.e.* those in the middle of the diagram, have a death rate of +0·40, and the cold winters a rate of +0·14, a better value than that of the average winters.

The summer diagram is of a very different character. The hot summers have a death rate of +1·35, the average summers of +0·13, and the cold summers of −1·28. These figures mean that in England if a summer be exceptionally hot, there are about ten thousand more deaths than usual, and if exceptionally cold, there are about ten thousand less deaths than usual.

The *Weekly Returns* show plainly that extreme cold in winter and extreme heat in summer both increase the death rate; while the figures given above show that continued cold or warmth in winter has no very marked effect either way; but that continued heat in summer is most prejudicial, and continued cold most favourable to life.

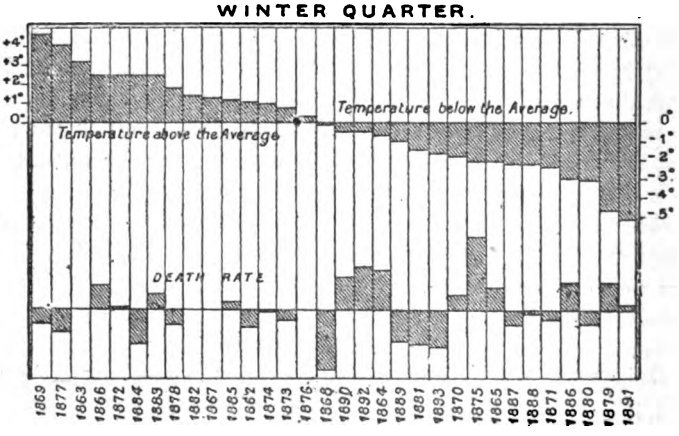

FIG. 1.

Since the lowest death rates occur in May, June, and October, and in England the winter death rate is much above the summer one, it has been thought that a temperature of 50°—55° was most favourable to life, and that the death rate increased in proportion to the extent to which the temperature departed from this value. The curves given by Dr. Buchan for New York do not bear this out, for though the winter temperature there is 10° below

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that of London there is no corresponding increase in the death rate. It must not be forgotten that the difference between summer and winter is not only one of temperature; indeed, in England the temperature difference is trifling when compared with that of other countries; but it is also one of the duration of daylight.

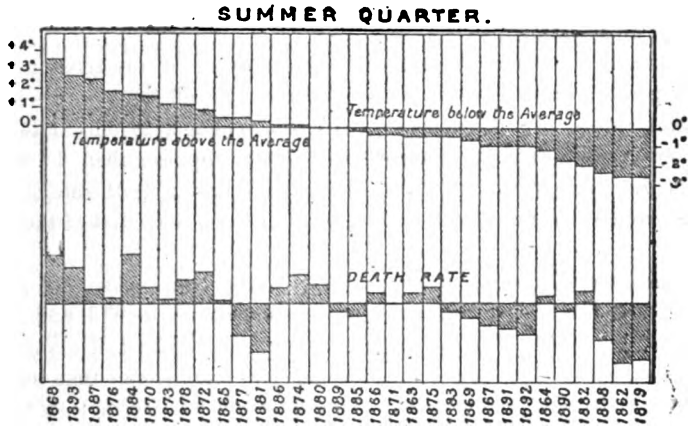

FIG. 2.

Absence of daylight means the increased use of artificial light, and in so far as the contamination of the air is concerned, one common gas burner is equivalent to four or five adults. The way in which overcrowding affects the death rate is well known; and there can be little doubt that, with the utter indifference to any proper ventilation that prevails, most of our population live in the winter in air that is greatly overcharged with carbonic acid. This is a possible explanation of the higher winter death rate, although it may perhaps be due to the direct absence of sunlight. The question is a most important one, for if my suggested explanation be correct, the general introduction of good ventilation, or the use of the electric light in the place of gas or lamps, would greatly reduce the rate, whereas if the high rate be due to temperature or the absence of sunlight owing to latitude, it is clear that no human agency can alter it.

DISCUSSION.

Dr. C. T. WILLIAMS, in a communication to the Secretary, said:—"This paper is an attempt to trace a connection between the mean quarterly temperature and the death rate, as based on the Registrar-General's returns for 32 years, and displays much ingenuity of thought, but not very reliable conclusions; for how can we judge of the effect of heat or cold without taking into consideration moisture, wind, and other elements? Again, the death rate must be analysed before any conclusions as to its connection with the weather can be drawn; for the outbreak of some epidemics of a purely contagious character will take place in any condition of the atmosphere and cause a high mortality, which should not be referred to the temperature of the air."

Dr. R. BARNES said that his experience of statistics of mortality had led him to the conclusion that unless such figures were very carefully analysed, fallacious results were likely to be obtained. There were many other considerations be-

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sides that of temperature which exercised a disturbing effect on the death rate, and it was necessary to take such into account when discussing the connection between weather and mortality. Sunshine was an important factor in the preservation of health, and he was in the habit of advising his patients to "take as much sunshine as they could get." In the winter months the amount of outdoor exercise was considerably curtailed by reason of inclement weather, and there were many conditions during that season of the year which served to make the winter more unfavourable to health than the summer. He called attention to the papers of Dr. Buchan and Mr. Latham as especially valuable in this relation.

Dr. A. BUCHAN said that, considering the paucity of data, considerable ingenuity had been shown in the manner in which the material had been handled. It was probable that much better results would have been obtained if the deaths from the various diseases had been dealt with. A hot summer was always attended with an excess of deaths from diarrhœa and bowel complaints, but a great deal of winter mortality was due to sudden changes of weather and indiscretion in the matter of changing and putting off garments. The most unhealthy winter weather was usually when the temperature ranged between 32° and 40°, the climatic conditions being of that description usually spoken of as "raw," and giving rise to affections of the throat. When the weather was dry and frosty with a low temperature, good health generally prevailed, the sharpness of the cold serving to stimulate the body and impart a generally healthy tone. It would have been a better plan for Mr. Dines to have made the temperature quarters and the death rate quarters synchronous, instead of commencing the temperature period a month earlier than the death rate period. The proverb that "a green yuletide makes a fat kirkyard" appeared to be intended to apply to those seasons when the weather previous to Christmas had been mild, as such weather was frequently followed by a sudden change to cold early in the ensuing year, and a large mortality usually resulted from the advent of sudden cold after a warm period. Hot weather in summer was most fatal to young children and old people, but the outdoor life possible in the summer season tended to increase health.

Mr. F. J. BRODIE said that there was no one who had at all studied the subject of the connection between weather and health but would agree that a mild winter and a cool summer were the best from a hygienic point of view, and that as a general rule the most "unseasonable" seasons were the most healthy. But while the conclusions which Mr. Dines had arrived at were correct, the method of dealing with the statistics embodied in the paper was not quite satisfactory. For instance, the average quarterly temperature at Greenwich was compared with the average quarterly death rate for the whole of England, but it was well known that the temperature of a season over even so small an area as England varied greatly in different localities. During the winter which had just ended (December 1893 to February 1894) the temperature in England SW, as given in the *Weekly Weather Report* published by the Meteorological Office, was 0°·1 below the average, but in England S it was 0°·7 above the average, and in England NW, the temperature exceeded the average by as much as 1°·5; so that to take the temperature at one place and compare it with the death rate for the whole of England was an objectionable method. It was to be regretted, too, that the quarterly averages of temperature and mortality were for different periods. He (Mr. Brodie) had tabulated statistics of the death rate and temperature in London for several years past, and found that, owing to the different methods of working, there were considerable discrepancies between his own results and those given in the paper. In several cases a season which was said to be healthy or unhealthy over England generally was the very reverse in the metropolis, the locality from which Mr. Dines had derived his temperature values. A striking instance of this occurred in the winter of 1890-91. In the paper this is quoted as a winter with an average death rate, but in London the total mortality was 8 per cent. above the average, while the deaths from diseases of the respiratory system were as much as 38 per cent. above the average. There was at the time no epidemic of influenza, and the unhealthiness of the season might therefore fairly be attributed to the persistent low temperatures and to the undue prevalence of fog.

Dr. W. MARCET said that he agreed with Mr. Brodie in his objection to the

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average temperature of Greenwich being compared with the death rate of the whole of England, as there were often great variations in the weather in even one season over different parts of the country. During the winter of 1890-91 the weather was very severe in the south of England, and the cold was prolonged over several weeks, but in Scotland he believed the weather was wetter and warmer than the average. There was no doubt that very cold weather killed a number of old people, and that extremes of temperature increased the death rate. It would be interesting to know, in view of Dr. Nanssen's expedition to the North Pole, what the effect of a term of years spent in Arctic temperatures would be upon the human body. He heard it stated by the monks at the Hospice on Great St. Bernard (8,000 feet above the sea), who were all young men of strong constitution, and selected as best fitted to endure the rigorous climate, that most of them suffered in health after living a year on the mountain, and after two or three years' stay were unable to remain any longer.

Mr. G. J. SYMONS said that in comparing death rate and temperature he did not think it was desirable to adopt identical months, as there must be some interval between the weather influence and the entry of the deaths ensuing from it. Moreover, Mr. Dines had evidently taken identical quarters as well as the meteorological quarters, as he says, "It may be added, that had the civil instead of the seasonal quarter been taken, the results would have been substantially the same."

Mr. W. H. DINES, in reply, said that his only knowledge of the subject was contained in the table he had given, and in the deductions that might fairly be drawn from it. With reference to Dr. Williams' and Dr. Barnes' remarks as to sunshine and moisture, he did not think that moisture, considered simply as the amount of rainfall, made much difference; and he believed that others who had worked at the subject had come to the same conclusion. With regard to sunshine, he had no figures showing its prevalence since 1862; but it would require very strong evidence to make him suppose that sunshine could be anything but favourable in the winter. It was different in the summer; and if it was then healthy, its effect was completely overmastered by the accompanying heat. Thus the dull, gloomy summers of 1879 and 1888 had been very healthy, but the almost uninterrupted sunshine of 1868, 1884 and 1893 had given the three highest death rates in the list. With reference to epidemics, he thought that they were seldom widespread enough to greatly influence the returns from a population of 25 millions, and that the few instances in which they had done so were unimportant, when taken in connection with a period of 32 years. He thought that Dr. Buchan's remark that a temperature between 32° and 40° was the worst to be very probable, and further investigation might show that this explained the figures for the winter months. Certainly it applied to 1891, in which the unusual phenomenon of some six weeks with a temperature below 32° had occurred. He agreed with Mr. Brodie in thinking that the more unseasonable the weather the more healthy, if unseasonable meant a mild winter and a cold summer. He had taken the Greenwich temperatures because they were so easily obtained; no doubt the differences from the average at Greenwich were not always the same as the differences in other districts, but on the whole he thought they were fairly representative of England, excluding of course Scotland and Ireland. He had taken the whole country, and not London only, for the death rate, because accidental variations, due to a local epidemic, or a period of London fog, for example, would be more likely to be eliminated. As a general rule the town and country death rate rose and fell together, although Mr. Brodie had instanced one case, namely the summer of 1882, in which they did not do so. His plan of taking different periods had been criticised; but, as Mr. Symons had pointed out, he (Mr. Dines) had taken the trouble to ascertain that the conclusions reached would have been the same if the other plan had been adopted. He had, when preparing the paper, been in considerable doubt on the point, but had been chiefly influenced by the returns relating to diarrhœa. Mr. Symons had given another reason, which had not previously occurred to him. In conclusion, he said that he thought that the death rate curve for the winter quarter appeared to have no connection with the temperature curve, but that the steady slope of the summer curve from left to right showed plainly the deleterious effects of heat and the beneficial effects of cold.

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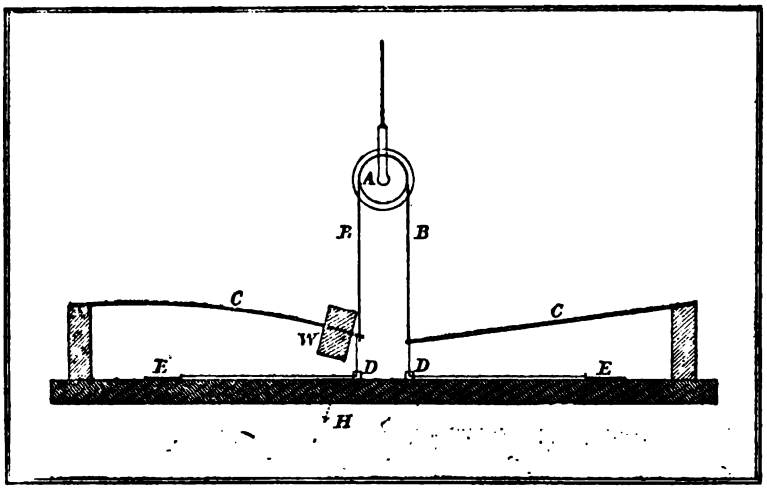
On the Duration and Lateral Extent of Gusts of Wind and the Measurement of their Intensity.

By W. H. DINES B.A., F.R.Met.Soc.

[Received February 21st.—Read March 21st, 1894.]

The Royal Commission appointed to inquire into the Tay Bridge disaster recommended that in similar structures allowance for an extreme wind pressure of 56 pounds per square foot should be made. This estimate seems to have been based on the automatic records of the pressure given by the Osler pressure plate at various observatories, but it is thought by some engineers, who are well qualified to form an opinion, that such high pressures as 56 lbs. per square foot do not occur in England. As a matter of fact much higher pressures have been recorded, and the whole question reduces itself to this: How much reliance can be placed on the correctness of the instruments?

In my opinion the attempt to obtain a record of the mean pressure and also of the maximum pressure by the same instrument is hopeless, and



I now proceed to give an account of some experiments and observations which show that the maximum pressure given by the ordinary spring plate depends far more upon what may be called the "personal equation" of the instrument than upon the force of the wind.

An extremely light pulley, *A*, was fastened to the end of the cord coming from a foot circular pressure plate. A string, *BB*, was placed over the pulley, the ends of which were fastened to two exactly similar springs, *CC*.

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The springs were formed of tempered steel, of about $\frac{1}{8}$ by $\frac{3}{8}$ section, and 1 foot long, one end of each being rigidly fixed. One spring was loaded at the moveable end by a 2lb. weight, *W*.

The maximum deflexion of each spring was recorded by tying a piece of cotton to the free end, passing it under a staple, *D*, and attaching a light aluminium index, *E*, to the other end. On raising the spring the index is drawn over a horizontal scale, and it, of course, does not return when the spring is released. The scales were made by applying definite weights and noting the position to which the indices were drawn. They were found to be exactly alike, and were carefully checked from time to time.

From the form of this apparatus it is clear that a force applied with any approach to steadiness must give the same result upon both scales. The actual results obtained from observations made during the past winter are shown in Table I., the first column giving the value from the loaded spring and the second column the simultaneous value from the unloaded spring.

A glance at these figures shows how greatly the momentum of a pressure plate influences the maximum pressure which it records. It can be shown mathematically, or by direct trial upon the apparatus, that a sudden jerk, the force not being sustained even for an instant, causes the unloaded spring to give the higher value; but that a jerk, the force being sustained even for a second, causes the loaded spring to give the higher value.

Neglecting the "moment of inertia" and friction of the pulley, we see from elementary mechanical principles that the forces applied to each spring are always equal; yet the differences of the deflexions produced are sometimes as great as 50 per cent.

It would appear from the figures in Table I. that the heavier a plate is the more likely it will be to give too high a value, for as a rule the loaded spring shows an excess over the unloaded.

It is also worthy of note that the weight attached to the spring produced quite a dent in the wooden frame of the apparatus at *H* by hammering against it; although it required a downward force of 1 lb., equivalent to a negative pressure of 2 lbs. on the plate, to make it touch the wood. A thrust cannot be transmitted through a flexible cord, hence the dent could only be caused by the oscillation of the spring; and if it often swung below its zero position, it follows inevitably that it must often also have gone the same distance too far on the other side.

It is possible that the aluminium indices were sometimes jerked into a position not warranted by the deflexion of the spring, but this would be more likely to happen with the one in connection with the unloaded spring than with the other. If so, it still more confirms my opinion as to the unreliability of the records. It is very probable that this jerking of the pen and pen carriage is the true explanation of the enormous pressures that are recorded. It is remarkable that Bidston Observatory is famous for high pressures, and, if the traces given in the Tay Bridge report are exact copies, the scale at Bidston is the shortest, and consequently, if the pencil is jerked an inch or so too high, it will have more effect on the record there than elsewhere.

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The difficulty of measuring a rapidly varying quantity is not confined to meteorology, but in other branches of science the instruments used for this purpose are designed so that they may be adapted for the work they have to do. The indicator diagram of a steam engine, for example, would not, I imagine, be of much value if the diagram were drawn by an apparatus similar to the ordinary recording pressure plate: yet the variations of wind force seem to be almost as rapid as the variations of the steam pressure in the cylinder of a steam engine.

I think that the momentum of the plate itself often adds 30 to 50 per cent. to the real pressure, and that the sudden jerk transmitted through the chain or wire often brings the pen or pencil another 50 per cent. above its proper place. Mr. Ellis has told us how substituting a flexible chain for a wire reduced the Greenwich pressure, and it is not unreasonable to suppose that if the chain also had been done away with, and the clock and drum placed close behind the plate, a still greater reduction might have occurred.

The pressure plate is a most useful anemometer and gives most interesting results, including a perfectly accurate mean pressure. If it were provided with a rack and catch, so that it could not oscillate, but once driven back by the wind could not return until set by the observer, the record of the mean would be lost, but the record of the maximum would be reliable.

TABLE I.—IDENTICAL MAXIMUM PRESSURES REGISTERED BY LOADED AND UNLOADED SPRINGS.

Loaded Spring.	Unloaded Spring.	Per-centage.	Loaded Spring.	Unloaded Spring.	Per-centage.	Loaded Spring.	Unloaded Spring.	Per-centage.
lbs. per sq. ft.	lbs. per sq. ft.		lbs. per sq. ft.	lbs. per sq. ft.		lbs. per sq. ft.	lbs. per sq. ft.	
3·2	3·0	107	7·0	6·4	109	7·2	6·2	116
4·8	2·8	171	7·4	5·0	148	10·1	6·2	163
2·4	2·0	120	7·0	8·2	85	4·8	3·6	133
2·0	1·4	143	12·0	7·5	160	7·8	8·0	97
5·2	4·4	118	9·0	6·6	136	5·2	4·2	124
8·8	6·2	142	4·2	4·4	95	8·8	4·8	184
10·0	7·6	132	6·1	5·0	122	17·6	8·6	204
8·0	7·0	114	14·1	8·5	165	5·8	4·4	132
4·8	5·2	92	18·0	15·0	120	6·0	4·6	130
4·8	4·0	120	7·0	5·2	135	3·8	2·8	136
4·8	5·2	92	7·0	9·6	73	10·0	11·2	89

The preceding results give no information as to the duration of the gusts, but only show the great suddenness of the variations. For this purpose the tube anemometer has been used. This instrument has been described before,[1] and the description need not be repeated. The maximum recorded depends just as much on the particular instrument as it does with the pressure plate, but by contracting the tube which holds the liquid, or either of the pipes which transmit the pressure from the head, it can be damped in a very convenient way.

[1] *Quarterly Journal*, Vol. XVIII., p. 168, and Vol. XIX., p. 17.

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Two similar glass tubes were obtained and bent to exactly the same curve. They were partly filled with coloured paraffin oil and fixed on a frame side by side touching each other, with a velocity scale underneath. The ends of the tubes being connected with the head of the anemometer, the two columns of coloured oil moved up and down together, registering exactly the same maximum velocity for each gust of wind. A piece of tube of $\frac{1}{32}$ in. bore and about 8 inches long was then inserted between one tube and the head, the other being left as before. The maxima recorded for the same gust by these two tubes are given in Table II.

TABLE II.—Maximum Velocities registered by Open and Contracted Glass Tubes worked by the same head.

Open Tube.	Contracted Tube.	Open Tube.	Contracted Tube.	Open Tube.	Contracted Tube.	Open Tube.	Contracted Tube.
Miles per hour.	Miles per hour.	Miles per hour.	Miles per hour.	Miles per hour.	Miles per hour.	Miles per hour.	Miles per hour.
27	22	37	31	41	39	55	53
31	27	43	33	48	44	44	40
29	25	32	30	50	49	53	45
19	15	33	31	50	48	54	46
28	24	44	41	45	42	63	58
34	27	22	22	53	49	72	68
30	26	56	52				

A large number of observations have been made, and they all present differences similar to those given in the table, which have been taken just as they came and not selected in any way.

I really used five tubes, but since it soon appeared that the maximum registered was strictly proportional to the amount of damping brought into play, the observations from the intermediate tubes were discontinued. The figures given refer to the two extremes.

It was found by experiment that the sudden application of a pressure corresponding to 40 miles per hour, the tubes then indicating zero velocity, produced the following effects:—

The liquid in the open tube rose to 48—44, owing chiefly to its momentum, but partly because some little of it remained sticking to the glass, there not being time for it to settle to its true level. The liquid in the damped tube rose steadily, it never exceeded the 40 miles per hour, but took from five to six seconds to reach that value.

We do not know how the gusts rise, so we cannot imitate them artificially, but during a gale in which the maximum velocity, as registered by the open tube, is about 60, the minimum will not as a rule fall below 20.

The motion of the liquid during such a gale, which has occurred twice this winter, viz. on December 12th and February 11th, is most interesting. It consists of a perpetual oscillation between the limits of about 30 and 50, sometimes rising and falling steadily, and sometimes by sudden jerks. So

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far as I have observed, however, an upward jerk is hardly ever followed instantly by a downward jerk.

It appears from Table II. that the extreme force of the wind is hardly ever maintained steadily for so long as five seconds. If it were the two tubes would give maxima much nearer together. Also since the damped tube never falls so low as the other, it has not so far to rise, and would not take nearly five seconds to reach its maximum; hence I am inclined to think that a gust seldom maintains its full force for more than one or two seconds.

It must be remembered that in Table I. pressures are given, and velocities in Table II. Since the pressure varies as the square of the velocity, the percentage difference of the pressure deduced from Table II. will always be more than double the percentage difference of the velocities.

The same two glass indicating tubes were used to determine as far as possible the lateral extent of the gusts. Neither of them was damped, and they were connected with two separate but exactly similar anemometers, placed at the same height, viz. 18 ft., but 11 ft. apart, over the top of my house.

The maxima given by the tubes for the same gust are shown in Table III.

TABLE III.—MAXIMUM VELOCITIES REGISTERED BY TWO TUBE ANEMOMETERS PLACED 11 FEET APART.

North-west Anemometer.	South-east Anemometer.	North-west Anemometer.	South-east Anemometer.	North-west Anemometer.	South-east Anemometer.	North-west Anemometer.	South-east Anemometer.
Miles per hour.	Miles per hour.	Miles per hour.	Miles per hour.	Miles per hour.	Miles per hour.	Miles per hour.	Miles per hour.
51	54	72	75	55	55	36	45
43	44	50	47	47	47	52	50
43	48	47	44	42	40	56	56
55	62	56	55	48	47	41	49
53	50	47	50	48	38	51	49
53	53	58	56	43	43	53	49
63	65	48	50	31	35		

It will be seen from the figures that even at so short a distance as 11 ft. apart the extreme force exerted is sometimes very different, but this is more fully borne out by direct observation of the instruments during a strong wind. It is perfectly apparent that the gusts often, in fact generally, strike the heads of the anemometers at different instants, and it often happens that the liquid in one tube is rising while that in the other is falling.

The tubes were interchanged several times, but the exact similarity of the two instruments, and the fact that sometimes one and sometimes the other gives the actual maximum, shows that the differences could not possibly be due to the instruments, but must be a real phenomenon.

One anemometer was south-east of the other, and the differences are always greatest with a South-west or North-east wind, in fact with a South-

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east wind the two columns of liquid often move together as though they were rigidly connected. From this I gather that the extreme velocity mostly occurs in lines which are roughly parallel to the direction of the wind.

It would be very interesting to carry this investigation further, but the conditions of exposure do not render it possible for me to do so at Oxshott. It is apparent to any one who carefully watches the motion of the trees in a gale that the gusts are of no great extent laterally. It is impossible to indentify the gusts that pass over a prominent poplar tree about 300 yards from any sitting room window with those that agitate the nearer trees.

I am quite aware that at an exposed coast station the wind is not so gusty as it is inland, but the traces given by the bridled anemometer at Holyhead certainly do not lead to the conclusion that it is at all steady even there. In this anemometer there is no chain or wire, the pencil being rigidly connected with the cups to which the wind pressure is applied. As a result, velocities which give a pressure exceeding 30 lbs. per square foot are extremely rare, although the recent gale in this neighbourhood, which gave a pressure of 37 lbs. at Greenwich, would probably by comparison have been but a gentle breeze to the gale of November 18th-19th, 1893, at Holyhead.

The late Mr. Hawksley, at one time President of the Institution of Civil Engineers, is stated to have said that "the instruments at present in use are little better than philosophical toys, and that in general they afford no direct comparable or reliable indications of either velocities or pressures."[1] So far as velocities are concerned, I hope this is not true now, although we still print all our records of velocity without comment, knowing the amount given is some 30 per cent. too high; but so far as records of maximum pressure are concerned, I do not myself think they are worth more than the paper on which they are printed.

DISCUSSION.

Mr. W. Airy said that he so entirely agreed with Mr. Dines's conclusions that he had no criticism to offer upon the paper. He was fully in accord with Mr. Dines's statement that "the attempt to obtain a record of the mean pressure and also of the maximum pressure by the same instrument is hopeless." The maximum pressures recorded by the Osler pressure plate were too great, although no doubt the instrument recorded the mean pressure accurately. But while the mean pressure was of some value, the maximum pressures were the most important and useful, as it was those which caused damage to structures. He had noticed that the Osler pressure plate never really faced the wind when struck by a gust, the gust appearing to have the effect of making it oscillate sideways, so that the full force of the wind did not act upon the plate. Sir John Fowler had deputed to him the arrangement of the anemometers for the Forth Bridge experiments, and he erected two anemometers, one fixed with its front in the direction from which the strongest winds usually came (a little South of West), and the other moved by a vane. He predicted that the greatest pressure would be recorded by the fixed anemometer, and the results fully bore out his expectations. In connection with the Forth Bridge it was important to test the lateral extent of gusts, and for this purpose a large pressure plate 20 feet by 15 feet was constructed. It being too heavy and awkward a thing to attach to a vane, it was fixed in a similar position to that of the small fixed anemometer,

[1] *Quarterly Journal*, Vol. VIII., page 29.

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and he believed it was found that the maximum pressures per square foot on this 800 feet area were about two-thirds of those registered by the small plates. It would be interesting if Sir John Fowler would publish the results of the observations that were made with these pressure plates. The lateral extent of wind gusts was an important factor, and one that it was desirable to know in order to ascertain the amount of pressure exerted over a large area of ironwork, such as the Forth Bridge; but the sea appeared to be the only suitable place for making such observations. Some interesting particulars bearing on this point were given by Capt. Watson in a letter which he (Mr. Airy) had received when Secretary of the Tay Bridge Commission. Regarding the duration of gusts, he (Mr. Airy) had never observed a violent gust which maintained its maximum pressure for so long a time as one second.

Mr. R. H. CURTIS said that Mr. Dines had again referred to what was without doubt a grave fault in Osler's pressure plate anemometer, namely, the tendency of the momentum of the plate to exaggerate the record; but he thought a still more serious, because at present still less understood, drawback to the instrument lay in the fact that it was impossible to compare *inter se* the records of instruments which differed as to size and shape of plate. Experiments which he had himself made with plates of different areas and shapes showed that the stream lines on their surfaces varied very greatly with changes in both directions, and from these and other facts he concluded that the pressure per unit of surface must certainly be less on large than on small plates. This fact, combined with the errors due to momentum, and—in some cases at any rate—others due to arrangements adopted for conveying the movement of the plate to the pencil, made the records from this form of instrument unreliable. With reference to the lateral extent of gusts, he could not agree entirely with Mr. Dines's conclusions. It was very evident that in the neighbourhood of trees and houses the currents of air must become much broken up, and under such conditions they would be very different from what they would be at sea, or on a perfectly open plair. Mr. Dines's vanes were placed upon the roof of a house, with gables and a roof which sloped from the walls up to a flat top, and the country round is undulating and well wooded; under such conditions eddies would be numerous and inevitable, and it would be impossible to predict their character or extent. Anyone watching squalls travelling over the surface of the sea or of a large sheet of water, would notice that while they generally cover a considerable extent of surface, in some cases they are very extensive indeed. Then, with respect to the duration of gusts, he was also unable to endorse what had been said by Mr. Dines and Mr. Airy. It was a point to which he had given a great deal of attention for many years, and lately he had spent a good many hours by the side of Mr. Dines's pressure tube anemometer, watching the action of the pen in squalls of wind. That instrument entirely confirmed what he had previously observed, namely, that gusts of wind rarely come on with their full force all at once, but by a succession of steps or pulses, and he had certainly often noticed the pen to remain at its highest point for longer periods than had been mentioned.

Mr. R. W. MUNRO inquired whether Mr. Airy could state the difference in weight per square foot between the large and small pressure plates used at the Forth Bridge Works.

Mr. W. AIRY said that he was unable to give the figures asked for by Mr. Munro off hand, but the difference was considerable.

Mr. W. H. DINES, in reply, said that he considered that the maximum pressure was the most important, but he was certain that it could not be obtained from a plate that was free to oscillate. He had found that in certain cases the wind pressure was greater when the air struck the plate at an angle than when it struck it perpendicularly, and this might perhaps explain why Mr. Airy had sometimes obtained the greatest pressure on a plate which could not turn to the wind. His experiments had also shown that the greater the plate the less proportionally was the pressure upon it. He agreed with Mr. Airy in thinking that the greatest force was often not maintained even for a second, but it did not necessarily follow that Mr. Curtis was wrong in his belief, for some gusts might not last for a second, while others might maintain their full force for five seconds. This appeared from Table II., which gave some instances of close agreement between the two tubes, thus showing that the gust lasted some few

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seconds. Replying to Mr. Curtis, he said that his two anemometers were 18 ft. above the ridge of the house, and he was inclined to think that they were high enough to be free from eddies.

ON THE CALCULATION OF PHOTOGRAPHIC CLOUD MEASUREMENTS.

By Dr. K. G. OLSSON,

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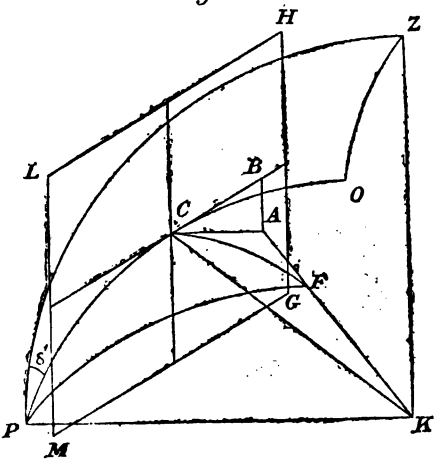
[Received December 27th, 1893.—Read March 21st, 1894.]

In consideration of the importance which measurements of the height and motion of clouds have obtained in recent times, I have, at the request of Dr. N. Ekholm, undertaken to develop formulæ adapted to the computation of photographic cloud measurements. Because, with observations of this kind, the photographic plate takes up so vast a field of view, that approximative formulæ giving the requisite precision cannot be used except for those parts of the image near to the optical axis, exact formulæ must be deduced by solving the spherical triangles and must then be brought into a form convenient for numerical work. In the first place formulæ will be given for measurements with the "cloud equatorial," described by Dr. N. Ekholm,[1] and then, shortly, formulæ applicable for instruments of the theodolite type.

Fig. 1.



1. Let a sphere of arbitrary radius (Fig. 1) be drawn so that its centre K coincides with the centre of the photographic object glass, and let a tangent

[1] *Quarterly Journal.* Vol. XIX. p. 38.

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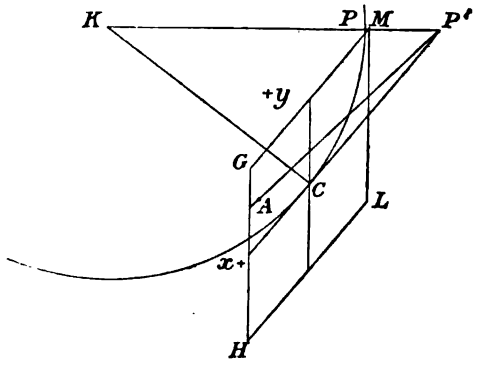
plane $GHLM$ of this sphere be drawn, touching it in the point C, where the optical axis KC meets its surface, then all the photographed objects will be projected in this tangent plane. Also, provided the object glass be good and the plate exactly perpendicular to the optical axis, the image on the photographic plate will be a projection perfectly similar to the former. Supposing this to be so, let POZ represent a part of this sphere, P being the point where the axis of the instrument, when produced, meets the surface of the sphere, the "pole" of the instrument say, and KZ the vertical line. Let A be the point in the tangent plane, the spherical coordinates of which are to be determined, and F the point, where KA meets the spherical surface, then the arc $PF = \alpha$ and the spherical angle $FPZ = \delta$ are the coordinates sought. I suppose α to be reckoned from KP upwards from 0° to 180°, and δ from 0° to +90° or −90° on each side of the vertical plane KPZ of the instrument. The arc $PC = \alpha'$ say, and the spherical angle $CPZ =$ the arc $OZ = \delta'$ say, will be found by reading the circles of the instrument, and may, of course, be considered as known. Then a system of coordinates must be drawn in the photograph with its origin in the image point corresponding to C, and the coordinates of the image point of A must be measured on the plate. Thus, the problem will be to compute α and δ by means of α' and δ' and those coordinates.

2. For this purpose, let (Fig. 2) K represent the inner principal point of the object glass. Then, to the tangent plane $GHLM$ in C (Fig. 1) corresponds the photographic plate $GHLM$ (Fig. 2). If then a sphere be drawn

Fig 2.



through C with its centre in K, it will touch the photographic plate in C, and if the straight line KP be drawn from K parallel to the axis of the instrument, the point P corresponds to the "pole" of the instrument (P in Fig. 1). The great circles drawn through P will be projected, as will be shown below, as straight lines on the photographic plate, and they will all meet in the point P' where KP produced meets the plane of the photographic plate. The dihedric angle formed by any great circle with the vertical plane will represent a value of δ, and the corresponding values of α will be

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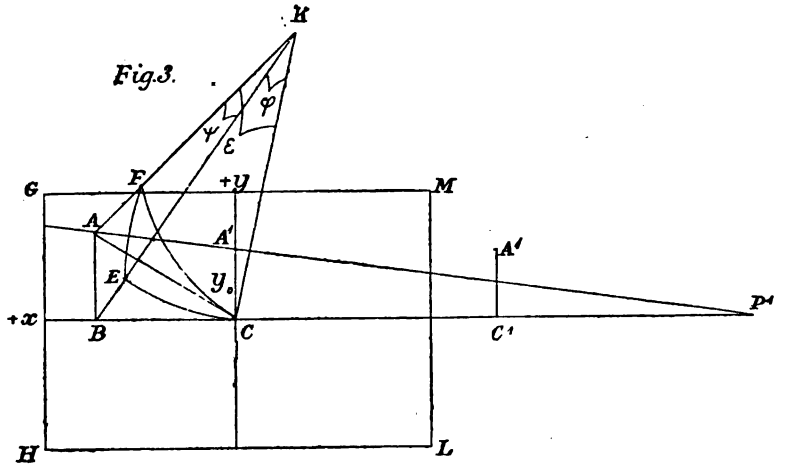
measured along the periphery of the great circle from P downwards. Thus we may conveniently call them "α-great circles."

3. Now let (Fig. 3) the photographic plate be laid in the plane of the paper, the line CK being directed upwards, and then, taking C as the origin, let two axes of rectilinear coordinates be drawn perpendicularly in such a way, that the axis of x touches the α-great circle of the sphere, the positive directions being taken so that x is increasing with α and y with δ; thus $CB=x$ and $BA=y$ will represent the coordinates of A in this system. If an apparatus for measuring polar coordinates be employed, $AC=r$ and the plane angle $ACB=\Theta$ are the corresponding coordinates, where, of course, Θ ought to be reckoned from the left to the right, viz. from the positive x-axis to the positive y-axis. Now let us introduce the auxiliary angles $BKC=\phi$ and $AKB=\psi$, and, moreover, for the second case (polar coordinates) $AKC=\varepsilon$.



Method I. Rectangular coordinates.

The plane ABK meets the sphere drawn through C with its centre in K along the arc of great circle EF and the plane BCK along the arc EC. Thus the arc EF is $=\psi$ and the arc $CE=\phi$. The triangle BCK, rectangular at C, gives, if CK be put $=k$, k being an instrumental constant,

$$x=k\tan\phi \quad \ldots \quad \ldots \quad (1)$$

From the same triangle we obtain

$$BK=\frac{CK}{\cos\phi}=\frac{k}{\cos\phi}$$

and from the triangle ABK, rectangular at B,

$$y=AB=BK\tan\psi$$

by which

$$y=\frac{k\tan\psi}{\cos\phi} \quad \ldots \quad \ldots \quad (2)$$

By means of (1) and (2) ϕ and ψ can be computed.

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Method II. Polar coordinates.

The plane ACK (Fig. 3) intersects the sphere along the arc of great circle FC, thus the arc FC is $=\varepsilon$ and the spherical angle ECF is $=\Theta$. The triangle ACK, rectangular at C, gives

$$r = k \tan \varepsilon \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

from which ε can be calculated. Then the spherical triangle CEF, rectangular at E, gives:

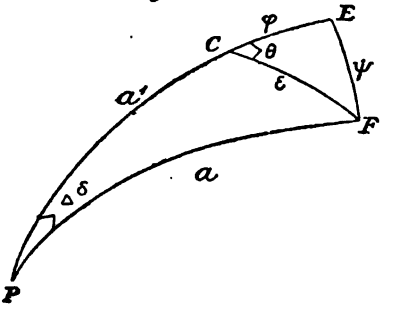
$$\left.\begin{aligned} \sin\psi &= \sin\varepsilon \sin\Theta \\ \cos\psi \sin\phi &= \sin\varepsilon \cos\Theta \\ \cos\psi \cos\phi &= \cos\varepsilon \end{aligned}\right\} \quad \ldots \quad \ldots \quad (4)$$

by which

$$\left.\begin{aligned} \tan\phi &= \tan\varepsilon \cos\Theta = \frac{r\cos\Theta}{k} \\ \tan\psi &= \tan\Theta \sin\phi \end{aligned}\right\} \quad \ldots \quad \ldots \quad (5)$$

4. Now let the superficial triangle CPF in Fig. 4 be the same triangle as CPF in Fig. 1, separated from the rest, and let the arc of great circle

Fig. 4.



PC be produced so as to meet at E the great circle EF drawn from F perpendicular to PC, then again we find $EC = \phi$ and $EF = \psi$. Also, putting

$$\Delta\delta = \delta - \delta'$$

we obtain from the rectangular spherical triangle EFP,

$$\left.\begin{aligned} \sin a \sin\Delta\delta &= \sin\psi \\ \sin a \cos\Delta\delta &= \cos\psi \sin(a'+\phi) \\ \cos a &= \cos\psi \cos(a'+\phi) \end{aligned}\right\} \quad \ldots \quad \ldots \quad (6)$$

from which

$$\left.\begin{aligned} \tan\Delta\delta &= \frac{\tan\psi}{\sin(a'+\phi)} \\ \tan a &= \frac{\tan(a'+\phi)}{\cos\Delta\delta} \end{aligned}\right\} \quad \ldots \quad \ldots \quad (7)$$

Here it must be observed that, for the numerical calculation, it is not

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necessary to know ψ, but only $\tan \psi$, and therefore the first of the formulæ (7) is more suitably written in the following manner :—

$$\left.\begin{aligned} \text{I.}\quad \tan \Delta\delta &= \frac{y \cos \phi}{k \sin (\alpha' + \phi)} \\ \text{II.}\quad \tan \Delta\delta &= \frac{\tan \Theta \sin \phi}{\sin (\alpha' + \phi)} \end{aligned}\right\} \quad \ldots \quad \ldots \quad (8)$$

where I. is to be used for rectangular coordinates and II. for polar ones.

The above formulæ are developed for the one of the two cloud equatorials, but can immediately be applied also for the other, if everywhere α is changed in β (compare Dr. Ekholm's formulæ (1)). Thereby it is to be observed, because the angles α and β are taken in opposite directions, and as the positive axis of x is drawn in the same direction as α increases, that the two photographic plates are symmetrically equal, viz. if they be laid with the positive y-axis in the same direction, the positive x-axis will lie in opposite directions, and consequently also the angle θ must be reckoned from the positive x-axis in opposite directions.

5. In his paper "A new instrument, etc." Dr. Ekholm indicates the advantage of being able to draw corresponding lines on the two photographic plates. Those are evidently each pair of lines, for which the coordinate δ is the same, and, as now will be shown, those lines are straight. For in Fig. 2 let a plane turn round KP', then the sections between this plane and the sphere will be the α-great circles, and accordingly, the images of all the objects, that have the same δ, must all lie in the straight line, along which the turning plane intersects the plane of the photographic plate. In order to construct those lines, let us cut off from C on the axis of x a length (Figs. 2 and 3)

$$CP' = k \tan \alpha' \text{ (the numerical value)}$$

in the negative direction, if $\alpha' < 90°$, and in the positive direction, if $\alpha' > 90°$. Then, according to Fig. 1, the angle $CKP =$ the arc $CP = \alpha'$, and thus the projection of CP on the tangent plane will be

$$KC \tan \alpha' = k \tan \alpha'$$

so that P' will be the point where all these straight lines meet. Thus if the photographic plate be fastened on a drawing table, these lines (for instance AP' in Fig 3) may be drawn with a rule. If CP' be so great that the point P' cannot be conveniently employed for the construction of the lines AP', which may be the case for α' between 80° and 100°, a scale (C_1A_1) drawn perpendicularly to CP' in a point (for instance $C_1 = \frac{1}{2} CP'$) may be employed instead of P'.

This proceeding may also be applied in order to obtain a third method for determining $\Delta\delta$.

Method III.

Let $CA' = y_0$ (Fig. 3) be the part of the axis of y cut off by any of the lines $P'A$. Then an expression for y_0 can be found in the following manner.

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In Fig. 2 let a plane be laid through C and the axis of y (or CA') perpendicular to KP, and let it cut KP in H (Fig. 5). The triangle $A'CH$, rectangular at C, gives, the angle $A'HC$ being $= \Delta\ \delta$,

$$y_o = A'C = CH \tan \Delta\ \delta$$

but

$$CH = KC \sin \alpha' = k \sin \alpha'$$

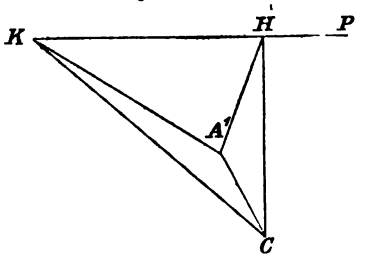
thus

$$y_o = k \sin \alpha' \tan \Delta\ \delta$$

from which

$$\tan \Delta\delta = \frac{y_o}{k \sin \alpha'} \quad \ldots \quad \ldots \quad (9)$$

Fig. 5.



In order to find the corresponding line on the other plate, we have :—

$$y_o' = k' \sin \beta' \tan \Delta\ \delta,$$

k' being the instrumental constant of the other instrument, analogous to k for the first. As then the quotient

$$\frac{y_o'}{y_o} = \frac{k' \sin \beta'}{k \sin \alpha'}$$

is a constant for the two plates, the corresponding lines are easily drawn.

For an instrument of the theodolite type P' is the image on the plane of the photographic plate of the zenith point, and the straight lines AP' are the images of the vertical circles. As, however, the two instruments are deprived of the advantage, that exists in the cloud equatorial, of having a common plane, these lines have not the quality, that one of the coordinates, which are to be determined, is the same for all the objects that lie on two corresponding lines.

6. If the formulæ above given are combined, the scheme will be as follows :—

Method I. Measuring of the rectangular coordinates x and y on the photographic plate :

$$\tan \phi = \frac{x}{k}\ ;\ \tan (\delta - \delta') = \frac{y \cos \phi}{k \sin (\alpha' + \phi)}\ ;\ \tan \alpha = \frac{\tan (\alpha' + \phi)}{\cos (\delta - \delta')} \quad \ldots \quad (10)$$

Method II. Measuring of the polar coordinates r and Θ :

$$\tan \phi = \frac{r \cos \Theta}{k}\ ;\ \tan (\delta - \delta') = \frac{\tan \Theta \sin \phi}{\sin (\alpha' + \phi)}\ ;\ \tan \alpha = \frac{(\tan \alpha' + \phi)}{\cos (\delta - \delta')} \quad (11)$$

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Method III. Graphical construction of the α-great circles and measurement of x and y_o :

$$\tan(\delta-\delta') = \frac{y_o}{k \sin a'}; \quad \tan\phi = \frac{x}{k}; \quad \tan\alpha = \frac{\tan(a'+\phi)}{\cos(\delta-\delta')} \quad \ldots \quad (12)$$

With regard to the determination of the quadrants in which the angles ought to be taken, we observe that ϕ lies between $-90°$ and $0°$, when x or $\cos\Theta$ is negative, and between $0°$ and $+90°$, when x or $\cos\Theta$ is positive; that $\Delta\delta$ lies between $-90°$ and $0°$, when $\tan\Delta\delta$ is negative, and between $0°$ and $+90°$, when $\tan\Delta\delta$ is positive; and that α lies between $0°$ and $90°$ when $\tan\alpha$ is positive, and between $90°$ and $180°$ when $\tan\alpha$ is negative. For instruments of the equatorial type uncertainty can never arise, as the instruments can never be supposed to be directed so that their sight lines are nearly parallel to the common axis of the instruments (KP). For instruments of the theodolite type uncertainty can, however, arise at the determination of the quadrant of the azimuth, when observations are made near to the zenith; this will be considered later on.

The constant k, that is employed in the formulæ, will be determined by measuring the rectilinear coordinates of some well defined points in the photograph of an object on the earth, and then measuring the angular coordinates of the same points by means of the tube and circles of the instrument. For the same photographic plate $k \sin a'$ is also a constant, and thus Method III. is advantageous, if a great number of measurements are to be made on the same plate. Among the angles here employed, ϕ can be tabulated with x as an argument, as this angle is dependent only of x and the constant k.

If δ, α and β be calculated by means of the above formulæ, the following calculation will be performed by means of the formulæ given in the paper of Dr. Ekholm above mentioned.

7. I will now shortly give the formulæ that are applicable for instruments of the theodolite type.

In Fig. 6, let the great circle ZS represent the common vertical of the two instruments, from which the azimuth angles are supposed to be reckoned with watch-hands (sunwise). KC is supposed to be the optical axis of the instrument produced, ZC is the zenithal distance, z', read on the circle of the instrument, the spherical angle CZS the azimuth, say a'. The tangent plane in C corresponds to the photographic plate. The coordinate axes are supposed to be drawn in the tangent plane so that the axis of x touches the vertical circle in C, and the coordinates taken in the same direction, in which the corresponding spherical coordinates (z' and a') increase.

For the sake of perspicuity let in Fig. 7 the spherical triangle ZCF be separated from the rest. If we put

$$\Delta a = a - a'$$

and if the two auxiliary angles ϕ and ψ be introduced, defined as before, we obtain

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$$\left.\begin{aligned} \sin z \sin \Delta a &= \sin \psi \\ \sin z \cos \Delta a &= \cos \psi \sin (z' + \phi) \\ \cos z &= \cos \psi \cos (z' + \phi) \end{aligned}\right\} \quad \ldots \quad \ldots \quad (13)$$

and the following systems of formulæ :—

I. Rectangular coordinates.

$$\tan \phi = \frac{x}{k}\,;\ \tan \Delta a = \frac{y \cos \phi}{k \sin (z' + \phi)}\,;\ \tan z = \frac{\tan (z' + \phi)}{\cos \Delta a} \quad \ldots \quad (14)$$

II. Polar coordinates.

$$\tan \phi = \frac{r \cos \Theta}{k}\,;\ \tan \Delta a = \frac{\tan \Theta \sin \phi}{\sin (z' + \phi)}\,;\ \tan z = \frac{\tan (z' + \phi)}{\cos \Delta a} \quad \ldots \quad (15)$$

Fig. 6.

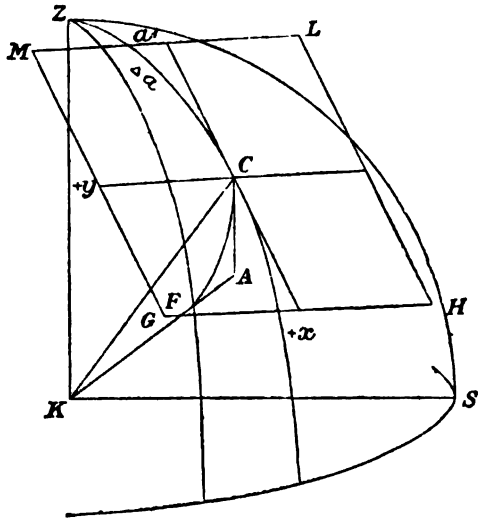
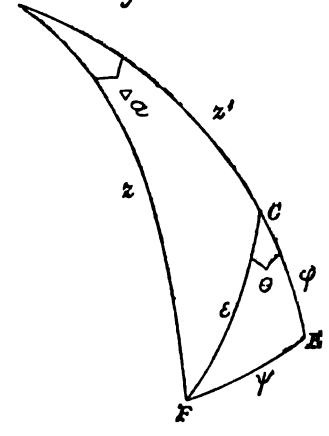


Fig. 7



Here it must be observed that Θ ought to be reckoned from the positive x-axis, from the left to the right, in both instruments.

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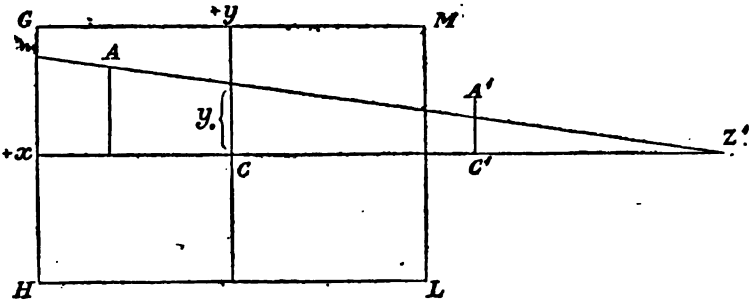
III. Measurement of x and y_o.

In Fig. 8 let the rectangle $GHLM$ be the photographic plate, laid in the plane of the paper. Z' is the projection on the photographic plate of the zenithal point Z. The straight lines, that are the images of the vertical circles on the sphere, all meet in Z', which, as the zenithal distance never is greater than 90°, always lies on the negative x-axis in a distance from C:

$$CZ' = k \tan z'$$

Fig. 8.



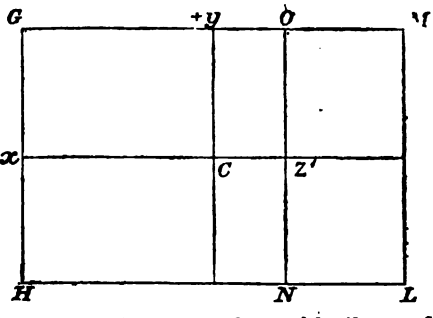
By laying a plane through the y-axis perpendicularly to the zenithal line KZ in Fig. 6 we obtain:

$$y_o = k \sin z' \tan \Delta a$$

Thus the formulæ in this case are:

$$\tan \Delta a = \frac{y_o}{k \sin z'}; \quad \tan \phi = \frac{x}{k}; \quad \tan z = \frac{\tan (z' + \phi)}{\cos \Delta a} \qquad \ldots \qquad (16).$$

Fig. 9



When observations are made near to the zenith, the quadrant of Δa is determined as follows. Because the angles ϕ and ψ can always be supposed numerically less than 90°, the first two formulæ (18) prove that $\sin \Delta a$ has the same sign as $\sin \psi$, and $\cos \Delta a$ the same sign as $\sin (z' + \phi)$. But according to the formula

$$y = \frac{k \tan \psi}{\cos \phi}$$

$\sin \psi$ has the same sign as y, and from Fig. 9, analogous to Fig. 8, we find,

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that if the point A to be measured falls to the left of the line NO drawn through the image Z' of the zenith point parallel to the y-axis, $z'+\phi$ is positive, and if A falls on the right of NO, $z'+\phi$ is negative. Thus sin Δa has the same sign as y, and cos Δa the same sign as $x+k \tan z'$. Thus, if the point A falls within the rectangle GZ', Δa ought to be taken in the 1st quadrant,

if A within MZ', Δa in the 2nd quadrant
" LZ', " 3rd "
" HZ', " 4th "

Numerical Example.

$a' = 47° 30·'3$; $\delta' = +34° 56·'7$; $y = +32{,}5$ mm.; $x = +28{,}6$ mm.;
$k = 125{,}8$ mm.

Method I. Formulæ (10)

*	$\log x = 1·4564$	$\log y = 1·5119$
*	$\log k = 2·0997$	
	$\log \tan \phi = 9·3567$	
	$\phi = +12° 48·'5$	$\log \cos \phi = 9·9891$
	$a' = 47\ 30·'3$	Sum $= 1·5010$
	$a' + \phi = 60\ 18·'8$	
		$\log k = 2·0997$
	$\log \tan (a' + \phi) = 0·2441$	$\log \sin (a' + \phi) = 9·9389$
	$\log \cos \Delta\delta = 9·9825$	Sum $= 2·0386$
	$\log \tan a = 0·2616$	$\log \tan \Delta\delta = 9·4624$
	$a = 61° 18'0$	$\Delta\delta = +16° 10·'3$
		$\delta' = +34\ 56·7$
		$\delta = +51\ 7·0$

Method II. $r = 43{,}29$ mm. $\Theta = 48°39·'0$

Formulæ (11)

$\log r = 1·6364$	
$\log \cos \Theta = 9·8200$	$\log \tan \Theta = 0{,}0555$
Sum $= 1·4564$	
$\log k = 2·0997$	
$\log \tan \phi = 9·3567$	
$\phi = +12°48·'5$	$\log \sin \phi = 9·3458$
$a' = 47\ 30·\ 3$	Sum $= 9·4013$
$a' + \phi = 60\ 18·\ 8$	$\log \sin (a' + \phi) = 9·9389$
	$\log \tan \Delta\delta = 9·4624$
$\log \tan (a' + \phi) = 0·2441$	$\Delta\delta = +16°10'·3$
$\log \cos \Delta\delta = 9·9825$	$\delta' = +34\ 56\ ·7$
$\log \tan a = 0·2616$	$\delta = +51\ \ 7\ ·0$
$a = 61°18'·0$	

* If ϕ be tabulated, the 3 rows are excluded.

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Method III. $y_0 = + 26{,}9$ mm.

Formulæ (12) $\log y_0 = 1{\cdot}4298\ \phi$ and α are calculated as shown in

$\log k \sin \alpha' = \underline{1{\cdot}9674}$

$\log \tan \Delta\delta = 9{\cdot}4624$ the first vertical row in Method I.

$\Delta\delta = + 16^\circ\ 10'{\cdot}3$

$\delta' = + 34\ \ 56{\cdot}7$

$\delta = + 51\ \ 7{\cdot}0$

ADDITION TO THE ABOVE SOLUTION GIVEN BY DR. OLSSON.

BY NILS EKHOLM, Hon.Mem.R.Met.Soc.

A later consideration of Dr. Olsson's formulæ for the equatorial photogrammeter has suggested the following simplification of the formulæ (1) given in my last paper[1] combined with those of Dr. Olsson.

Let ϕ_1 and ψ_1 denote the auxiliary angles for the first equatorial, ϕ_2 and ψ_2 those for the second, and for the sake of shortness put $\alpha' + \phi_1 = A$, $\beta' + \phi_2 = B$.

Then by the formula (6) of Dr. Olsson

$$\left.\begin{aligned} \sin\alpha \sin\Delta\delta &= \sin\psi_1 && (1)\\ \sin\alpha \cos\Delta\delta &= \cos\psi_1 \sin A && (2)\\ \cos\alpha &= \cos\psi_1 \cos A && (3) \end{aligned}\right\} \text{I.}$$

$$\left.\begin{aligned} \sin\beta \sin\Delta\delta &= \sin\psi_2 && (1)\\ \sin\beta \cos\Delta\delta &= \cos\psi_2 \sin B && (2)\\ \cos\beta &= \cos\psi_2 \cos B && (3) \end{aligned}\right\} \text{II.}$$

$\Delta\delta = \delta - \delta'$ being the same for a corresponding point at the two instruments.

Multiplying I. (2) by II. (3) and I. (3) by II. (2) and dividing by $\cos\Delta\delta$ we get

$$\sin\alpha \cos\beta = \frac{\cos\psi_1 \cos\psi_2}{\cos\Delta\delta} \sin A \cos B$$

$$\sin\beta \cos\alpha = \frac{\cos\psi_1 \cos\psi_2}{\cos\Delta\delta} \sin B \cos A$$

and by addition

$$\sin(\alpha+\beta) = \frac{\cos\psi_1 \cos\psi_2}{\cos\Delta\delta} \sin(A+B)$$

Also multiplying I (2) by II (2) and dividing by $\cos^2\Delta\delta$,

$$\sin\alpha \sin\beta = \frac{\cos\psi_1 \cos\psi_2}{\cos^2\Delta\delta} \sin A \sin B$$

Introducing these values in our formulæ (1) cited above we obtain

$$\left.\begin{aligned} x &= \frac{b \sin B \cos A}{\sin(A+B)} = b - \frac{b \sin A \cos B}{\sin(A+B)}\\ y &= \frac{b \sin A \sin B}{\sin(A+B)} \cdot \frac{\sin\delta}{\cos\Delta\delta}\\ z &= \frac{b \sin A \sin B}{\sin(A+B)} \cdot \frac{\cos\delta}{\cos\Delta\delta} \end{aligned}\right\} \text{III.}$$

[1] *Quarterly Journal.* Vol. XIX. p. 42.

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where

$$A = \alpha' + \phi_1,\ B = \beta' + \phi_2;$$

α' and β' are read on the circles of the equatorials and ϕ_1, ϕ_2, $\Delta\,\delta$ and δ are found as shown in Dr. Olsson's paper. Thus we need not calculate α and β.

There may be a slight difference between δ'_1 and δ'_2 and between δ_1 and δ_2 (notation analogous to that used in my cited paper, p. 43) due to instrumental errors; if such be the case, the arithmetic mean of δ_1 and δ_2 and of $\Delta\delta_1$ and $\Delta\delta_2$ must be introduced in the formulæ III.

Then the shortest distance Δ between the sight-lines will be

$$\Delta = \frac{2b}{\cos \Delta\delta} \sin \frac{\delta_1 - \delta_2}{2} \frac{\sin A \sin B}{\sin (A+B)} \ldots \ldots \text{IV.}$$

The formulæ III as well as the formulæ (1) above cited combined with Dr. Olsson's formulæ are both very convenient for numerical work, so that a double calculation by means of the two systems will give an excellent control.

Similar simplifications are not applicable for the theodolite photogrammeters, as for them generally $\Delta\alpha$ is different for a corresponding point at the two instruments.

DISCUSSION.

Gen. R. STRACHEY, in a communication to the Secretary, said:—This paper may be regarded as being supplementary to that of Dr. Ekholm (*Quarterly Journal*, Vol. XIX. p. 38). It is designed to supply more exact formulæ for the calculation of the position of clouds obtained from photographic pictures, by the adoption of spherical coordinates instead of rectilinear; the discussion being made to embrace the cases both of cameras mounted as theodolites, and equatorially as proposed by Dr. Ekholm. Whether such refinements in computations of the heights and position of bodies so indefinite in their nature as clouds, are likely to be of practical value is perhaps questionable, and it would have been instructive to have had examples of actual observations treated with both in the approximate and more accurate manner for comparison. If, as is by no means improbable, the unavoidable uncertainties are much in excess of the differences brought out by the two methods of computation, the additional refinement seems uncalled for. The system last tried at Kew, by which the cameras were fixed with their optical axes directed to the zenith, may be regarded as a particular case of Dr. Ekholm's equatorial mounting. By it the direct comparison of the two sets of pictures got at the ends of the base, was made possible by simple superposition, and such a system might perhaps be extended so as to get directly comparable pictures from any point in the heavens, which would admit of almost all calculation being avoided, and the results being treated almost as simple "observations."

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ON SOME PHENOMENA OF THE UPPER AIR.

An Address delivered to the Royal Meteorological Society, April 18th, 1894.

By RICHARD INWARDS, F.R.A.S.

President.

It must be confessed that the human family are not placed in the best position for entering upon the study of the upper air, for we are on the wrong side of the earth's envelope for this purpose, and our position has been compared to that of an oyster at the bottom of the English Channel, trying to form some notion of the play of the waves and currents above by observing the small eddies and tremors which find their way to the little nooks and corners which constitute his domain at the bottom of the sea.

We have indeed done a great deal towards accumulating accurate particulars of the state of the air in its lowest layers, but the great field of research above us is still but little known, and we have to guard against attaching too much importance to minute and multitudinous observations below, while we are but too apt to neglect the broader researches into the great aerial ocean which is ever flowing above our heads, and out of our immediate reach.

It is the dream and aspiration of every meteorologist to know something more of this ocean of air, and it must be in the domain of this higher meteorology that the further conquests of our science must be won.

There are three principal ways in which the higher atmosphere may be studied.

First, by going and living in it, somewhere on one of the great mountain chains which rise many miles into the air in various parts of the globe;

Second, by ascending into it by means of balloons; and

Third, by the study of the upper currents, as shown to our sight by the movements of the clouds.

I shall have a few words to say on each of these methods of observation, and I must ask the Fellows to forgive me for adopting a less technical style in these remarks than that to which they are accustomed within these walls. My reason is a sufficiently good one (next to that of my own shortcomings), and is, that the subject is so vast that I should have little chance of finishing in one short hour were I to give anything but a rapid and general glance at the subject.

If we imagine an observer provided with optical aids similar to our own, and viewing the earth, say from somewhere on the darkened part of our own moon, such a person would be able to take a much more comprehensive view of the movements of the air than we can ever obtain, for he would see masses of clouds wandering over oceans and continents, desert wastes, and polar

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spaces, and, having the advantage of a comprehensive view of a hemisphere at once, he would not be long, at any rate with respect to the great cloud-bearing currents, in forming just notions of their movements.

The earth would be to him a splendid object about 16 times as large as the sun, and probably the brightest and most beautiful feature to him would be the ever shifting veil of clouds which he saw spread over its surface. In some of the densest, and to him brightest spots, we should, however, perhaps be suffering all the horrors of storm, thunder and wreck, small commotions which would be quite invisible from the point of view which we have just imagined.

One of the first questions to be asked, and one of the last to answer satisfactorily, is, How thick is the envelope of air which surrounds the earth? This is one of the things about which little consolation will be obtained by referring to meteorological works, for the various authors hover between 20 and 500 miles in their estimates of the height of the air.

But although we have no definite knowledge of where the atmosphere really ends, we are well acquainted with the sum total of its weight, and we know that at a height of about 3 miles half of its mass is below our feet. We are told, too, that the air cannot reach further into space than the point where the force of gravity is so diminished by distance as only just to equal the natural repulsive force with which the atoms of air (like those of all other gases) are striving to get away from each other. It is not too much to hope that experiment will some day enable us to fix this point.

Now the first way that I mentioned of extending human knowledge in an upward direction is by climbing a high mountain, and by living at a great height, to endeavour to study while actually in it some of the properties of the higher air. Dr. C. Theodore Williams, a few months since, gave us an interesting account of life in the higher altitudes of Colorado, and it has been my own lot to have lived on the great mountain chain of the Andes for about a year, and to have had opportunities of making notes which support the conclusions at which he arrived.

In these high plains of the Andes we get a good opportunity of studying the effects of rarefied air on animal life, and one of the first things we should expect in people who have to live in an atmosphere which only allows them to take in about two-thirds of the usual quantity of oxygen each time they breathe, would be that they would be sure to suffer from lung troubles, and that strangers coming from lower levels, where they had been accustomed to a full supply of that prime necessary of life, would fall ill or pine and die. Our surmises, though apparently founded upon reason, would be woefully wrong, for we should find ourselves among a people to whom lung diseases are almost unknown, who have no words in their language for consumption or catarrh, and who go about their daily occupations without ever suspecting that they are badly used in being deprived of so large a portion of their atmosphere. As to the stranger who arrives among them, after the first inconvenience caused by the sudden change, he generally improves in health, and if he had any chest disease when he came, he generally promptly loses it.

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Another thing which does not seem unreasonable is that birds, having but little more than half the density of air to beat against with their wings, would be unable to fly so swiftly or so far as those in lower air, but yet here we see the great Condor spreading his wings without an effort and sailing over the highest mountain peaks, while at 10,000 ft. altitude the little humming birds flit about hour after hour without even seeming to wish to settle.

I believe the eggs of birds are, at these heights, provided with a larger air bubble.

We find the men (I speak of the Aymará Indians, among whom I lived) to be a large chested and rather short legged race, with a great capacity for prolonged and patient exertion, but with no particular aptitude for great or sudden efforts.

One of the first things we notice here is that boiling water is not so hot, and certain kinds of food cannot be cooked at all by boiling. The sky is of a darker and purer blue. Sounds are not so loud, nor echoes so clear or frequently repeated as those below. Pumps and siphons do not raise water to the same height, fires will not give out so much heat, and furnaces which will melt certain minerals at ordinary altitudes will not do so here.

Exertion soon becomes fatiguing, and only a few yards running will cause a stranger to pant for breath.

The clouds are often seen widely spread out beneath your feet, and, just as in some of the pictures I hope to exhibit, one seems to look around on a wide sea of clouds, studded with blue islands, where the mountain tops pierce through into the sunshine, while the cloud-sea fills up the valleys, following every hollow and winding along every torrent bed, and showing bays and creeks without number, just as on the shore of a veritable sea or lake beneath.

In the high plains which we cross at night the electric effects are most startling, and I well remember my surprise at seeing brushes of flame issuing from the mules' ears while the arriero's spurs seemed like two fiery stars dancing near the ground. Every time we touched the manes of the animals a line of fire followed the hand, and a hissing noise was heard. These things are not rare, and I am prepared to believe that in Canada there are times when, as stated, an ordinary gas jet can be lighted by a natural spark from one's finger.

Then on these great mountain plains we often see whirling columns of sand (in form and motion like waterspouts at sea) careering along the vast dusty desert, and although one can sometimes see as many as six of these at once, yet it seems a rare thing to be actually enveloped in one. Their horizontal motion over the ground is quite leisurely, though there is a furious current of air and sand curling round in their centres.

The importance of high stations for weather observatories is fully recognised by other nations; and I need only name the gallant effort of Harvard College, who have, at their own expense, established in Peru an Observatory with full equipment of recording instruments on Mount Charchani at a height of 16,650 feet above the sea. When I tell you that this

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Observatory is more than 3,000 miles from the College, and is also in another country and hemisphere, some notion may be had of the effort necessary to establish and maintain it.

The second method of attacking the regions of the higher air is by means of balloons; and since Montgolfier first proposed to introduce French soldiers into Gibraltar by means of his balloon, there have been many ascents into the atmosphere by these means. Though the inventors did not at first venture themselves into the car of the balloon, yet Montgolfier proved the practicability of his scheme by sending up sheep and fowls, which duly came down alive.

It would be a task far too long to enumerate all the air voyages which have enriched science by the discoveries of new facts as to heat and moisture, wind and tempest, but in 1850 Messrs. Barral and Bixio found at 20,000 feet the temperature had sunk to 15° F. This was in a cloud, and on emerging from this 3,000 feet higher, the temperature sunk as low as −38° or 70° below freezing point. These voyagers, too, had the honour to be the first to pass through a cloud made up entirely of fine needles of ice, so that they managed to experience an arctic temperature in less than an hour's journey from Paris.

Then there were the memorable ascents made by our countryman Mr. Green, who was accompanied by Mr. Welsh, F.R.S., of the Kew Observatory (whose portrait on an old daguerrotype, and with a group of other celebrities, will be found in the Exhibition), and they confirmed previous observations as to the air becoming about 1° colder for every 300 feet rise. Mr. Green, too, was one of the first to witness two complete sunsets on the same day; for though he started from the earth some time after sunset, he rose so rapidly into the air that he soon saw the sun again, and watched it once more setting behind a more elevated horizon.

Then Mr. Creswick, of the Greenwich Observatory, made an ascent in a very old and damaged balloon, and after many perils came down, luckily, without accident.

But after these came the never to be forgotten series of ascents by our own Mr. James Glaisher, F.R.S., a former President of this Society, and a man still hale, though long past 80, who, with Mr. Henry Coxwell the aeronaut, also still living, undertook for the British Association a series of ascents provided with all the scientific apparatus necessary for a thorough examination of the currents of air through which they were to pass. They made 28 ascents, principally in a balloon made of American cloth, and not of silk, as the custom had been.

In the very first ascent some interesting facts were noted. At 15,500 feet the temperature had ranged between 26° and 31°, but after getting as high as 19,500 feet it was found to be 11° warmer, and just as they were taking off some of their thick clothing, they suddenly encountered a cold current of the temperature of 16°, all in a few moments. They came down with enormous rapidity, at the rate of about 4,000 feet in a minute, and they also sunk through a cloud 8,000 feet in thickness.

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In 1862 they made the ascent in which they reached an altitude never before attained and which has not since been surpassed, and they ran very great risk of perishing from the drowsy faintness produced by breathing the rarefied air. Mr. Glaisher collapsed, and although his brain retained for some time its thinking and observing powers, yet he found himself unable to move a single muscle and finally he fainted; while in the meantime Mr. Coxwell, whose hands were frost-bitten, only just managed to open the gas valve with the aid of his teeth, so as to enable them to descend from their seven miles altitude and to land safely on the earth. I can remember in these rooms hearing Mr. Glaisher's graphic description of his sensations when in a fainting condition, and his being "heckled" by a medical objector who seemed to see some difficulty in his account of the symptoms.

Mr. Glaisher has described in his *Travels in the Air* all the moving incidents in subsequent ascents, the grand cloud scenery passed through, the warm and cold currents, the layers of clouds at different heights, some of them raining freely into each other, the various effects of the rarefied air on themselves and on the pigeons they let loose from time to time, and he relates even so small a circumstance as the cork flying out of a water bottle owing to the expansion of the air within.

But there is a mode of getting information from balloons without undergoing the danger, and this is by sending up, instead of an observer, a series of instruments so cunningly contrived as to register the various changes of condition through which the balloon rises. This has just been done in France through the enterprise of M. Hermite, and the results are most interesting, for it appears that one of these balloons has surpassed all previous ascents, and has risen to a height of ten miles into the air and brought down automatic records of its journey. Mr. Green long ago expressed the opinion that it was useless to hope to ascend higher than ten miles even in a balloon inflated with pure hydrogen gas, but he probably reckoned on a living observer being carried up.

This French balloon rose to a point where the pressure was only 4·1 inches and the temperature −104 F. It seems from the results of this ascent that the temperature of the air decreases pretty regularly above 12,000 feet at the rate of 1° for every 330 feet rise into the air.

A word about the possibilities of the human animal taking to himself wings and flying into the space above. It may be said that a great many inventors have occupied themselves with the problem, and that it is only recently that they have been rewarded by the least glimmer of hope.

In the 15th century that wonderful Milanese who seemed to have combined within himself the powers of a host of masters,—I mean Leonardo da Vinci,—made many designs for flying machines, but in describing one of the most ingenious of them he let fall an observation which shows that he had not much faith in their success, for he writes to a pupil who was going to try the flight: "Thou wilt experiment with this instrument over a lake, and with a long leather bottle round thy waist, so that thou drownest not." Here we have an instance of an experimenter anticipating failure in what he

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attempts, but inventing a most useful thing (the life belt) as an accessory to the abortive scheme.

Herr Lilienthal has, however, actually made a flying apparatus with wings of 15 square metres, and he has succeeded at Steglitz, near Berlin, in flying, or rather gliding, through the air for a distance of 273 yards, always, however, slightly declining towards the earth, at an angle of from 10° to 15°. (See *Nature*, December 14th, 1893.)

In order to start, he has to run smartly a few steps against the wind, an evolution which the larger birds of prey have to perform when they rise from level ground. And we are told the same thing of our British bustard, now becoming so rare.

But as to this possibility of flight, although science cannot look to it for much aid, yet since the appearance of Professor Langley's *Experiments in Aerodynamics* the subject has entered another phase, and this truly eminent investigator gives it as his deliberate opinion that "mechanical sustentation of heavy bodies in the air combined with very great speeds is not only possible, but within the reach of mechanical means we actually possess, and that while these researches are not meant to demonstrate the art of guiding such heavy bodies in flight, they do show that we have now the power to sustain and propel them."

We now come to the third method of getting knowledge about what is going on above us, and this we can do by studying the behaviour of the clouds which float over our heads.

Aristotle defined a cloud as a mass of vapour floating in the air, and if we substitute water for vapour, or call it visible vapour, or as Tyndall named it "water dust," we shall not have much altered the twenty century old definition.

Clouds are simply a form of water made visible by the cooling of the air which previously held the water in the form of invisible vapour.

Every cloud may be regarded as the top of an invisible warm column or current thrusting its way into a colder body of air, and one point should not be lost sight of, that the clouds themselves sometimes form a barrier to the horizontal motion of the currents that produce them, and it is common in thunderstorms to see an enormous mass of cloud climbing higher and higher into the air till it seems to topple backwards upon itself like the cap of foam upon a gigantic wave.

It is of the greatest importance that meteorologists should agree on the names by which the various clouds should be known, and there is, I believe, an international scientific committee engaged in settling this point, and until we have their recommendations we can only go on using the names given them in 1803 by Luke Howard, an English Quaker gentleman, whose portrait you will see in the Exhibition, and who in his daily business walks studied well the sky, until he was able to frame a list of names for the clouds, by which names they have since been known all over the world.

But Mr. Symons, who is always unearthing some treasure, has called my attention to the work about the same time of Lamarck, who published in his *Annuaire Météorologique* a very careful system of cloud names.

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As early as the year 10 (not of our era, but of that of the first French Republic) he gave us a classified list of clouds. In the *Annuaire* for 1802 he divides clouds into :—

Nouages en voile. The veil cloud, which answers to our haze or mist.

Nouages attroupés. The gathered up or assembled clouds, which correspond generally to our cumulus and strato-cumulus.

His next class was that of *Nouages pommelés*, or dappled clouds, which are now known as cumulus.

He then describes *Nouages en balayures*, the swept cloud, which he compares to the marking left in dust by the action of a broom. This is clearly our mare's tail or cirrus cloud.

Then come *Nouages groupés*, or our cumulo-nimbus, the true thunder-cloud, which from a flattish base rises to a great height in the air with the upper borders always clearly cut against the sky, and described by him as rounded, lobed, mammellated, and festooned. He further makes the observation that the most rounded and clearly cut edges are always on the side towards the sun. He puts this down as a rule without any exception, and ascribes it to the impulses given by the sun's light to the vesicles of water forming the cloud, on the shady side of which, he says, one may see torn edges and fissures which contrast with the close texture and sharp margin of the sunny side.

He promised to embody all this in a book to be called *Théorie de l'Atmosphère*, but I do not know if he ever did so.

In the year 13 (of the French Republic) Lamarck had amplified his list to twelve classes of clouds, and his names may be freely translated as misty, bordered, veil-like, frame-like, inflated, barred, swept, dappled, gathered, racing, grouped, and thunder clouds.

Each of these classes he splits up into from three to six varieties, for instance, the barred cloud he divides into confluent, isolated, obscure, undulating, and partially dappled clouds, showing he was a careful observer of the cirrus group. In all, he describes 31 different varieties under separate names. He then describes 8 kinds of fine weather skies, 6 of medium, and 12 of bad weather. The whole treatise is interesting and well worthy of translation into English.

In 1808 the *Annuaire* had begun to count the years in the usual way, and had dropped the names of the months Nivôse, Pluvieuse, &c. for plain January and February, but had adopted what he called "meteorological" months as well as the usual ones.

The names given to the clouds by our own Luke Howard are, however, those most in use not only in England but in other countries.[1]

He called the lower clouds—almost resting on the earth,—*Stratus*, which we may for popular purposes call the sheet cloud.

Then came *Nimbus*, which is a rain cloud, then *Cumulus*, which is the heaped up accumulated, or wool-pack-shaped cloud of our summer skies.

Lastly the *Cirrus*, popularly known as the mare's tail cloud of every day talk.

[1] Howard's Classic Treatise has been recently reprinted in English by Dr. Hellmann. A. Asher & Co. Berlin, 1894.

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I will not here trouble you with the complete definitions as given by Howard, nor with the mixed varieties which are intermediate between the main forms already described, such as the cirro-cumulus or mackerel sky, which in popular phrase means "neither long wet nor long dry."

There are still simpler systems proposed, by ranging clouds under two heads, the striped, and the rounded stratus and cumulus, all the variations depending (say the advocates of this system) on the height in the air, the grouping and the position of the clouds, the same cloud which appears large and round near the earth becoming a mere dot when high up in the sky.

Whatever system of naming and classifying the clouds be adopted, it should depend on the heights of the various clouds in the air, and I shall hope to show you a few rough rules by which the comparative altitudes of the clouds may be judged, when there is no time or opportunity to make exact measures. Not one of these rules is infallible or strictly exact, but by keeping them in mind the observer will soon learn to know by a sort of acquired instinct whether a cloud is low or high. Even with the best instrumental means a liberal margin for error must be allowed, on account of the vague and transient forms with which one has to deal.

Nor is it really important to know to a foot or even a chain, how high a cloud is. It is enough if we can get a general and correct notion of the position of certain clouds as a class, for we may be very sure that inherent discrepancies will be at least equal to the errors caused by our defective modes of estimation.

The first indication of a cloud's height in the air is to be gathered from its *form and outline*. The softened forms are well known of the ground mists which creep along the earth's surface, and which can be seen rolling up the sides of hills or accumulating in a valley, and showing us that they belong to the lowest 5,000 feet, or, let us say, the lowest mile of the air. Then come the heaped up or rounded forms of the *Cumulus* which may be said to frequent the air between 1 and 3 miles from the earth's surface.

The mixed varieties of the heaped and striped clouds range between 3 and 4½ miles high, whilst from 4½ to 6, 8, or even 10 miles, we have the domain of the filamentous and feathery forms of the cirrus or mare's tail cloud.

The second indication of height is the shade or the shadow of the cloud. I shall call shade that darkness which is on the object itself—its shady side; but the shadow, or cast shadow, is the darkness caused on some other object by the intervention of the first between it and the light.

Now the low clouds and mists may be seen to have few shades or shadows, and these of so vague and indeterminate a character as not to arrest attention. But the clouds of middle air are distinguished by very definite shades and shadows too, while generally the upper clouds (over 4½ miles) have no shades, nor do they cast shadows, either on the earth or on each other. A painter puts them in with one sole colour.

The third indication of height is the apparent *size* of the cloud, and, roughly speaking, smallness in the cloud is an indication of greater height. The actual size may not vary much, but the same cloud seen at 1 mile

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and at 6 miles distance appears a very different object. The small spotted, and minutely subdivided, shadowless cirrus cloud is always high. Large cloak-like clouds belong to middle air. I am not taking the torn portions of the lower clouds, or the wrack, as it is called, into account, though these may be called small clouds also, but they are easily known by their rapid movements.

Another guide to the height is the apparent *movement* of the cloud; and as a general rule the quicker a cloud seems to move across the sky the lower it is. This is in accordance with the well-known sight seen from the window of a fast train rushing through a park-like country, where the nearer trees seem to gallop past at a furious rate, while the distant ones scarcely seem to move, or by contrast appear to be going in an opposite direction. As a matter of fact the upper clouds nearly always move much faster than the lower, and the speed of the upper air may often be very correctly estimated by watching the march of the cloud shadows over a tolerably level country. On February 2nd of this year (Candlemas Day), for instance, I noticed the cloud shadows coursing over Hampstead Heath at the rate of 48 miles per hour, just about double the speed of the wind on the surface of the earth.

The shape of the clouds, with their fronts well raised, like crests, showed, too, that the higher currents were moving still faster, and it must be remembered that the cloud cannot move so fast as the wind which drives it. As this observation of cloud shadows was made on Candlemas Day, when the sun shone brightly, it enables me to give another blow to an old superstition; for according to all weather wisdom, we should have had a second winter after that had happened. You all know how signally in this year the adage has failed. Old Candlemas or St. Valentine's Day was also sunny this year.

The fifth point of attack in estimating the height of some clouds is their perspective effect. I may say that this observation applies more particularly to one form of cumulus cloud, which is often seen rolling up in successive waves or bars, and which has given it the name of *Roll Cumulus*.

These are shown in the photograph by Mr. Davies, which I shall put before you; but first I must ask you to consider a diagram showing the difference in the perspective effect of the wave-like clouds according as they are higher or lower in the air.

Let the eye on Figs. 1 and 2 be that of a spectator looking at the sky through a plate of glass *B C*, and endeavouring to mark on the glass the places where he sees each wave of cloud. If the clouds are equidistant and low he will get the marks in the position shown in Fig. 1, *A*, where there is a *rapid* falling off in the spaces between the lines.

In the second case, where the clouds are high, he will get his marks on the glass plate more equidistant, as shown in Fig. 2, *A*.

So that it may be said of waves of cloud as of those of water, that the nearer the point of view is to their level the larger do the nearer spaces appear in comparison to the distant ones.

I show you actual photographs of these two characters of clouds, and I

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will have one of them inverted in the lantern for the purpose of showing how near is the resemblance between the waves of water and those of air, for if it were not for the ship upside down, you might easily take the appearance of these clouds for breakers rolling in upon the shore.

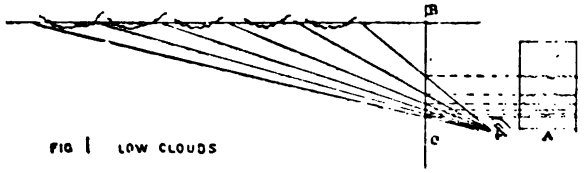


FIG 1 LOW CLOUDS

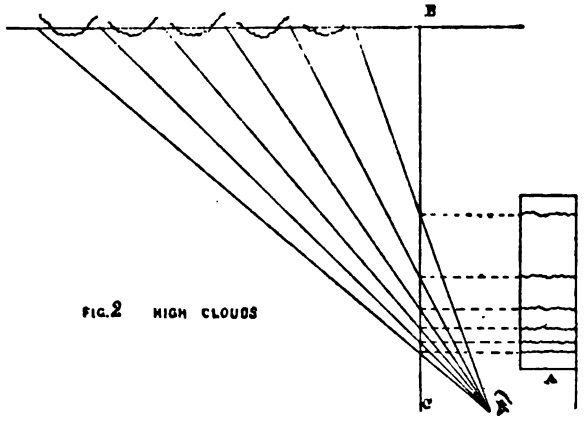
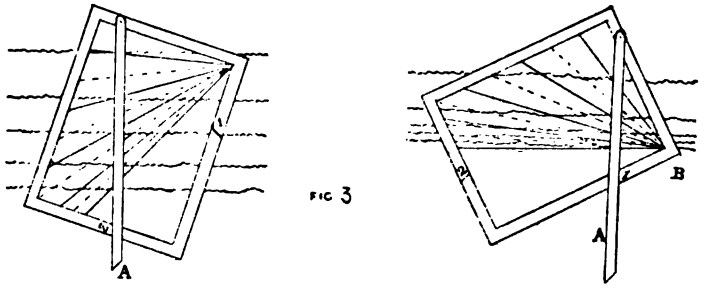


FIG.2 HIGH CLOUDS

I have made a little instrument to aid in this mode of estimating the altitude of clouds; it consists of an oblong frame with wires radiating from one corner, and with a bar, *A*, pivoted on the frame so as to cross the radiating wires at any angle. (Fig. 3.)



HIGH CLOUDS (2miles) FIG 3 LOW CLOUDS (1mile)

The instrument is so held between the eye and the clouds that the bar *A* seems to cut the wires in the same proportion as it does the horizontal cloud lines seen beyond. The bar *A* is always to be vertical. The position of *A* upon the frame indicates the height of the cloud series above the earth, which height would be infinite if the bar were parallel with the top of the frame and infinitely low when the bar is at right angles to the first position, and where the observer would be actually in the cloud.

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Of course it would apply to any equidistant bodies, such as trees or houses seen through it, and would give approximately the spectator's position with respect to them. I may say that every alternate wire or every alternate cloud may be taken if more convenient. It is also obvious that the same series of clouds seen from the earth, and again seen from the top of a very high tower, would require different positions of the bar to correspond with the effects seen from these different points of view.

The sixth way of forming a judgment of the cloud heights is also of limited application, but is of much greater accuracy, and it consists of observing for how long a time the cloud remains directly illuminated after sunset. In other words, how long a time elapses between sunset on the earth and sunset on the cloud. I must again ask you to look at a diagram (Fig. 4), only promising you that I will show you afterwards some of Nature's own work in the way of cloud pictures.

Let the circle be the earth supposed to be seen from a point above the North Pole. The arrow shows the way the earth is turning round from west to east at the rate of 15° per hour.

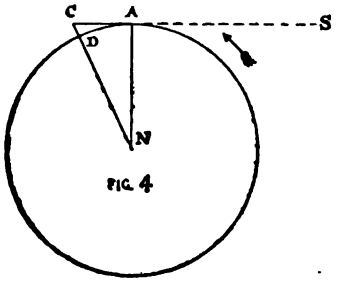

FIG. 4

S is the direction of the sun, which is of course just setting at *A*. When the earth has turned through 15°, so as to bring *A* to *D*, then a cloud would have to be as high as *C* to catch the sun's rays.

I have exaggerated the angle to make the principle clearer.

A N is the earth's radius, say 4,000 miles in round numbers, and *C D*, the height sought, is found to be the difference between what is called the secant of the angle (15° in this case) and the earth's radius multiplied by the said secant.

This is all plain sailing for the mathematician, as he has tables of these secants for every possible angle. In the case I have imagined the spectator is supposed to be on the equator, the sun's declination is zero, and the cloud is in the zenith, but it may be anywhere on a meridian. For other latitudes and seasons the case is more complicated, but I may say that under the conditions named, if a cloud caught the sun's rays 1 hour after sunset it would have to be 140 miles from the earth's surface, while if it could be conceived to be visible so long as 4 hours (during which the earth would have turned through an angle of 60°, the cloud or object would have to be 4,000 miles removed from the surface, because the secant of 60° is just double the radius. I found after working out this method that it had been previously applied by our esteemed Fellow, Prof. Archibald, in calculating the height of the zone of volcanic dust with which the volcano Krakatoa encircled the earth in 1883. Prof. Archibald, in the Report to the Royal Society, gives the whole formula, and I find that an American observer at Potosi has also used it in estimating the height of a particular group of clouds, and which he found to be 10 miles above the surface of the earth.

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I commend this to our merchant captains, who may find themselves becalmed in the doldrums, as they will there be under very favourable conditions for making the observations, which are very simple, and can be worked out at leisure; for the place of the ship, the date, and the moment of the disappearance of the sun's light from the cloud, are all the particulars necessary to note at the time. Full tables may perhaps be forthcoming to assist in this calculation.

Mr. Wingfield, an Australian observer, has proposed to estimate the cloud heights from the position of their shadows; but this method, though ingenious, is, I am afraid, impracticable on account of the difficulty of identifying at a distance the shadow of any particular cloud, also that the thickness of the cloud causes its distant shadow to be very different in proportions from the observer's view of the cloud itself.

Now all these methods come under the description of rough and ready rules; but the plan of taking the altitudes of clouds by the usual processes of trigonometrical surveying ought to be considered, but I can do no more than mention the general scheme, and give an illustration of perhaps the simplest possible case.

It is well known that if two angles and a side of any triangle are known, all the other measures of the triangle can be calculated, and it follows that if from the ends of an accurately measured base line on the ground two observers take simultaneously the angle which a line to the cloud forms with the base, then it is only a matter of calculation to compute the cloud's height.

If there should be one person present to whom this is not clear, I will put a more simple case, which might occur in estimating the height of a balloon (I take this because it is a more definite object than a cloud, but the principle is the same).

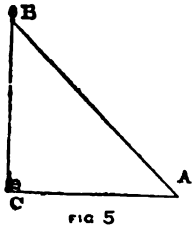

FIG 5

Let *B* (Fig. 5) be a balloon, which at a given time is vertically over some object, such as a church spire, *C*, and an observer at *A* is noting at the same time that a line to the balloon makes an angle of 45° (or half a right angle) with the ground. *A B C* then is half of a square divided diagonally, and therefore, as all the sides of a square are equal, *B C*, the balloon's height, is equal to the distance *A C* measured on the ground or on a map.

The merest guess at the height of a cloud from which rain is falling may be given by taking note of the size and speed of rain drops, and it is a common observation (how true I do not know) that when rain drops fall into water and throw up bubbles, the rain is likely to last a long time.

The cloud velocities at high altitudes have been carefully noted at the Blue Hill Observatory, near Boston, U.S., and show practically that at about 5 miles height the movement is three times as fast in summer and six times in winter, as compared with the currents on the earth's surface. In a new work by Prof. W. M. Davis, called *Elementary Meteorology*, there are many interesting facts about the speed of the wind at various altitudes. The rule seems to be that the higher the level the faster the movement, but there

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must, of course, be a level of maximum speed, though the position of this is not yet ascertained exactly.

I show you some pictures of stratus clouds, which must be regarded as the infant form of cloud hovering near its parent earth or sea. Sometimes it may be watched on a fine evening in summer melting away into the air like ice in water. The rate of disappearance is almost incredibly rapid, whole acres vanishing in a minute of time. In these cases the edges become smoother, and the fish-like shape of the cloud becomes apparent, and generally the rounded side is below and the flattest above.

As to the cumulus, or what may be called the adult form of cloud, I have already mentioned something about it in speaking of cloud heights, but the photographs, of which there are a great many, and generally very beautiful examples, will show you more than any verbal description.

There is one picture of what at first sight seems a cumulus cloud nestling under the falls of Niagara, but this is really a mass of ice constantly augmented by the freezing of the spray from the cataract. It is a fossil cloud, as it were, showing the lines and contours of its prototypes, which are floating in the air. It will be observed that this frozen cumulus grows by additions to its upper side.

Now the cirrus clouds, of which it is more difficult to give you any perfect examples on account of the difficulty of photographing them, may be considered as clouds in old age, and which have passed through the previous infantile and adult conditions I have already named. They are to all appearance moving much more slowly than other clouds, but this is only a deception which arises from their distance from the observer, they really move faster than the lower clouds. It is almost proved that they consist entirely of fine crystals of ice, because of the great cold at their altitude, which would not allow of the existence of vapour there. Then their effects in causing halos correspond with the known optical properties of ice, and in addition to these considerations, aeronauts have several times, when at great heights in the air, passed into cloudy masses of fine spicular ice.

Though cirrus clouds are generally relics and vestiges of other clouds, yet on their descent they have been observed to become centres of condensation and have again grown into the lower forms of cloud, and it is reasonable to suppose that the fine rain into which they would dissolve may sometimes be converted again into cloud before it has time to reach the earth. They seem, according to the Hon. Ralph Abercromby, to be found in all parts of the world, and it is, therefore, to be expected that those seen in the tropics are at a greater height than their polar cousins, also that they are more apt to form in cold nights after hot days, but as they are mostly invisible at night one cannot be certain if this is the case. It has not been my fortune to see cirrus clouds changing into any of the lower forms, but I have at sunset seen murky patches of lower clouds arrested under them and evidently ready to coalesce.

Cirrus clouds and their cirro-cumulus (mackerel sky) neighbours may occupy several layers of the atmosphere and move in different directions at

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various heights, and I exhibit to you a photograph of several strata of clouds one above another. Sometimes ice or snow particles will drop from the uppermost and pass through the whole series, getting successive coatings of ice varnish as they pass downward until they arrive on the earth in the form of enormous hailstones, the photographs of some of which I show you. This is without supposing the hail stones to make loops in their course and rise again into the clouds even more than once, a thing we know to be possible, from the effects of tornados which sometimes carry still heavier objects into the air. But all this is carefully gone into by the Hon. Rollo Russell in his excellent monograph *On Hail*. The same author has given us some valuable rules respecting cirrus clouds, and I only regret that he has not secured photographs of some of the quaint forms he so well decribes.

He has mentioned auroral cirrus, filmy cirrus, sheet or pallio cirrus, tufted or shower cirrus, fish bone or vertebrate cirrus, as well as radial, curdled, barred, and ribbed cirrus, but he does not propose these as names for adoption but only adjectives chosen by himself, for purposes of description.

The Rev. W. Clement Ley has also given new names to many varieties of the cirrus clouds, but we hope to some day see all his results in his great work on the subject. Mr. Gaster is also studying this subject.

With regard to some other matters concerning the higher air, one cannot avoid a few words of reference to what are known as the auroræ borealis or australis, literally the northern or southern dawns, as they were named by Gassendi, who acted as their godfather. They are sometimes seen in these latitudes, but never in the degree of splendour with which they paint the skies of polar regions. Professor Lemström, of Helsingfors, has given to the world, in his truly noble book on the subject, all that is certainly known of the phenomena, and he has added to his description a great many very striking drawings, two of which I can show you; but they are seen at once when magnified on the screen to want the finish and perfection of photographs. Professor Lemström not only studied the auroræ in the sky, but he actually produced a similar effect by an arrangement of rods and wires which sent long beams of naturally produced electricity into the air, closely imitating the real phenomena in kind if not in magnitude. Columns of light ascended from his apparatus more than 100 yards into the air.

The auroral displays of greatest brilliance occur at intervals more or less regular, corresponding with the periods of greatest magnetic disturbance, which in their turn appear in sympathy with the greatest number of spots which are seen upon the sun.

The height of the auroral display above the earth is found by Dr. Paulsen to range between 61 metres and about 67 kilometres, or, say, 41 miles, well within the limits of the atmosphere, though apparently the fiery trains never seem to reach the surface of the earth, and they have been observed lower in elevation the further north they have been met with.

Some of the auroral drawings give the notion of hosts of spear-armed warriors, and remind one of the passage in Julius Cæsar, where Calphurnia says she has seen—

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"Fierce fiery warriors fight upon the clouds
"In ranks and squadrons and right form of war," or again in the same play, when
"Exhalations whizzing in the air" are mentioned.

With the researches of Prof. Dewar before us on the liquefaction of the air, we can scarcely refrain from speculating as to what would be the electric effect if the upper air in Polar regions should actually liquefy and descend in a sort of cascade to be reconverted into air before it reached the earth. We are told that the cold measured on the surface sometimes descends in high latitudes to as low as −60° Centigrade, and it is not difficult to imagine that a few miles from the surface the temperature might sink another 120°, and that we should so obtain the conditions for converting the higher zones of air into a liquid. In a recent auroral display several observers remarked transverse patches like cirrus clouds crossing the general lines of the discharge.

Although not strictly a phenomenon of the upper air, I have the pleasure to show you a picture of a rainbow as photographed successfully by Col. Saunders, of Cheltenham. It will be seen that the space inside the bow is much more brightly illuminated than that outside, and the same thing is shown in a photograph by the Rev. F. C. Lambert, which you will see upon the walls. Regarding rainbows I may say that, under favourable conditions, they may be sometimes seen very near to noon, and I have seen one in Spain as late as 11.30 a.m. For this you require a mountain background to the north, and you may then get a low outer bow shown against the grey hills behind. This is, no doubt, (as Mr. C. L. Prince has pointed out) the rainbow at midday alluded to by Seneca, and which expression has been erroneously translated as a rainbow in the south.

There is also a photograph showing the corona round the sun, and Mr. A. Stroh is to be congratulated in having so well succeeded in depicting this beautiful effect.

For all these photographic illustrations we are grateful to those who have so successfully overcome the difficulties and have favoured us by lending their hard-won results.

To Professor Riggenbach, Mr. Cohen, Mr. Clayden, Mr. Davis, Mr. Stroh, Mr. Birt Acres, Mr Charters White, Col. Saunders, Admiral Maclear, Mr. Hussey, Mr. Hall, and to the Sciopticon Company we give our very best thanks.

I have to conclude by making a practical suggestion, and to urge the desirability of establishing somewhere in these islands a good cloud observatory. The times are ripe for such an institution, which need not be for a permanence, but which could do a great deal towards fixing our knowledge of the clouds and upper air currents, say in 10 years, or in even half that period.

The photographic facilities are now complete, the difficulties have practically vanished, and we have lenses which will command a quarter of the visible sky, we have plates which are specially sensitive to the red rays of the spectrum, and screens or mirrors which will filter off the too active blue-violet rays, and depict the most delicate markings even against a bright sky.

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Pictures may be taken in the most rapid succession by merely touching a trigger, and results can be printed as permanently as any document, legal or otherwise, which emanates from the press. We only want a suitable tower giving us a free horizon, and the benefactor to bear the expense.

The modest funds at the disposal of this Society would not enable us, unassisted, to undertake the inquiry, and one can only hope for some liberal augmentation to our research fund, founded by Dr. Williams, my predecessor, to help us on in this or other directions. Other nations are doing so much that England ought not to be behind.

This Society is not so much concerned with the bare utility of Meteorology as with making large additions to human knowledge in a skyward direction. We are encouraged in our pursuit, however, by the results which sometimes happen, even in a commercial sense, and M. de Parville, a French author, has estimated the saving to British navigation alone as 10 millions sterling per year resulting from the better knowledge of the course of winds and currents, which first became available after the publication of Maury's famous charts. It used, he says, to take 250 days to sail to Sydney and back from this country, and it can now be done in half the time.

Just as the Greek or Egyptian geometer, who first busied himself with the various properties of conic sections, could never have dreamed that long ages afterwards mirrors would have been constructed on his rules, which from lighthouses on every coast would flash a warning light over the ocean and be a boon and a blessing to the navigators of all future time—so in some measure is it with the study of the air, we go on feeling its pulses, examining its properties, and analysing its constitution, not merely with the hope of being able to reduce what seem to be its whims and caprices to an orderly sequence, and so to bind it to the service of man, but with the satisfaction which all civilised beings must feel in extending human inquiries further and further beyond the bounds of the known, into the vaster regions of the yet unlearnt.

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LUKE HOWARD, F.R.S.

(Frontispiece.)

As the subject selected for this year's Exhibition of the Royal Meteorological Society was "Clouds: their Representation and Measurement," it has been thought desirable that a portrait of Luke Howard, F.R.S.—who may almost be termed the father of English meteorology, and who was the author of Howard's cloud nomenclature—should be given in the *Quarterly Journal* along with the Catalogue of the Exhibition.

The portrait in the Frontispiece has been taken from a crayon drawing made by Bedford about 1843, and now in the possession of Mr. W. Dillworth Howard, F.R.Met.Soc.

The following biographical notice has been taken from the *Proceedings of the Royal Society*, Vol. XIV.:—

Luke Howard was born in London in 1772, a date which carries us back to the early years of the reign of George III., and opens a long vista of history in which great political changes are rivalled by the grandest discoveries of modern science.

Luke Howard's parents, members of the Society of Friends, sent their son to a country school in North Oxfordshire, where, as he was accustomed to say in after life, "he learnt too much of Latin grammar and too little of anything else." But having even then an observing eye, he began to notice the appearances of the sky and forms of clouds; and his inclination towards meteorology appears to have been fixed by his impressions of the remarkable atmospheric and meteoric phenomena which, as those acquainted with the history of meteorology will remember, characterised the year 1783.

From school young Howard went as apprentice to a chemist at Stockport, which was then a quiet country town. In this situation he devoted his spare hours to the course of self-improvement which he had already begun, and acquired that knowledge of French, botany, and the principles of chemistry which was so useful to him in after years. The quickening effect produced on his mind by the works of Lavoisier he described as "like sunrise after morning moonlight," an effect which has been felt by many a student.

In 1798 he entered into partnership with William Allen, whose reputation as a manufacturing chemist has long been recognised. This connection, however, was brought to an amicable close a few years later, and Howard, taking as his portion the laboratory at Plaistow, applied himself to the business therewith connected, and to his favourite scientific pursuits. Making use of his observations of natural phenomena, he wrote a paper *On the Modifications of Clouds*, and read it at a meeting of the Askesian Society, of which he and his friend Allen were members. This paper, as he himself tells us, "the result of his early boyish musings, enriched by the observations of many a walk or ride, morning and evening, to or from his day's work at the labora-

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tory," was published in 1803, and made known the author's name and ability to a wider circle. The Askesian was not a publishing Society; otherwise Luke Howard might have been better known than he is as a pioneer in departments of science besides meteorology. "I know," writes one of his friends, "that one or more of his papers related to atmospheric electricity, and another was an anticipation of the cell theory, as regards the structure and functions of plants, founded on microscopic investigations."

Many, if not all, the articles on meteorology in Rees's *Cyclopædia* were written by Luke Howard. He contributed a series of papers to the *Athenæum* embodying the results of his meteorological observations from the year 1806; and these he published in two volumes (1818-20), under the title *Climate of London deduced from Meteorological Observations made in the neighbourhood.* This, republished in 1833, in three volumes, has become one of our standard works on meteorology.

Luke Howard was elected a Fellow of the Royal Society in 1821. From that time his reputation as a meteorologist increased, and eminent persons in many parts of the world opened a correspondence with him, which, in some instances, became the initiation of a lasting friendship. Although the increased perfection of philosophical apparatus has superseded some of his methods of observation, there can be no doubt that his labours imparted more of scientific character to meteorology than it had ever received before. His classification of clouds is the one still recognised at all observatories,[1] and remains an evidence of the quick eye he had for form and colour, and of the daily labour which was to him a labour of love. One who knew him well in the latter part of his life says, "Those who lived with him will not soon forget his interest in the appearance of the sky. Whether at morning, noon, or night, he would go out to look around on the heavens, and notice the changes going on. His intelligent remarks and pictorial descriptions gave a character to the scene never before realised by some. A beautiful sunset was a real and intense delight to him; he would stand at the window, change his position, go out of doors, and watch it to the last lingering ray; and long after he ceased, from failing memory, to name the 'cirrus,' or 'cumulus,' he would derive a mental feast from the gaze, and seem to recognise old friends in their outlines."

Sharing in the active beneficence of the Society of Friends, Luke Howard readily aided endeavours for the religious and moral as well as the material welfare of the community. Not least important among these was the seeking to mitigate by pecuniary means the sufferings of the Germans during the campaigns immediately preceding the first abdication of Napoleon. In Ackworth school—a well known establishment of the Friends—he took a lively interest; and to participate the more directly therein, as well as to offer hospitality to the annual visitors to the school, he bought Ackworth Villa estate in 1823, making it his summer residence, and Tottenham his winter residence, during the greater part of his life.

In 1796 Luke Howard married Mariabella Eliot, a member of the same

[1] Written in 1864.

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Society with which he was himself connected. Of their family of seven children two sons only survived their parents. About his eightieth year he was much enfeebled by alarming attacks of illness; and the death of his wife following, after a union of fifty-six years, added sorrow to his weakness. Henceforward his life was a subdued waiting for the end. He died at Tottenham on the 21st March 1864.

Besides the works above mentioned he published—

Essay on the Modifications of Clouds, 1832;

Seven Lectures on Meteorology, 1837;

A Cycle of eighteen years in the Seasons of Britain, &c., 1842;

Barometrographia—Twenty years' variation of the Barometer in the Climate of Britain, 1847;

Papers on Meteorology, 1850-54; and

The Yorkshireman, a religious and literary Periodical in 5 Vols., 1833-37.

CLOUDS:
THEIR REPRESENTATION AND MEASUREMENT.

Catalogue of the Fourteenth Exhibition of Instruments,

Held, by permission of the Council of the Institution of Civil Engineers, at 25 Great George Street, Westminster, S.W.

APRIL 10TH TO 20TH, 1894.

INSTRUMENTS FOR ASCERTAINING THE DIRECTION AND HEIGHT OF CLOUDS.

1. **Goddard's Cloud Mirror.** *Exhibited by* F. C. BAYARD, F.R.Met.Soc.
2. **Cloud Mirror.** *Exhibited by* L. P. CASELLA, F.R.Met.Soc.
3. **Circular Cloud Mirror.** *Exhibited by* L. P. CASELLA, F.R.Met.Soc.
4. **Fineman's Nephoscope.** This consists of a tripod standing on levelling screws, bearing a compass needle in a circular brass frame moveable round a vertical axis. The lid of the compass case is formed of a mirror of black glass provided with a small circular window of clear glass through which the point of the needle is observed. The mirror bears on its surface radial lines for the principal points of the compass, and three circles distant (26·8 mm.) from each other. At the extremity of the diameter passing through the window, and opposite to it, is a vertical graduated scale moved by a ratchet wheel and milled head screw. The scale is raised or lowered till the image of a cloud seen at the centre of the mirror exactly coincides with the end of a line passing from the observer's eye through the point of the scale to the centre of the mirror. *Exhibited by the* METEOROLOGICAL COUNCIL.

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5. **Nephoscope devised by Lieut.-Gen. R. Strachey, F.R.S.** This consists of a circular mirror enclosed in a brass frame which is marked for eight points and for every 10°. Parallel lines distant 0·4 in. apart are ruled across the mirror, which is moveable round a vertical axis. Levelling screws are fitted to the instrument.
Exhibited by the METEOROLOGICAL COUNCIL.

6. **Nephoscope devised by Mr. F. Galton, F.R.S.** This consists of a circular brass frame standing on levelling screws. The bevelled edge is marked to eight points, and graduated to 10°. On this frame and moveable about a vertical axis is a mirror, and above it, moving with it, is a rectangular frame with five horizontal rods. The images of these horizontal lines can be brought into parallelism with the direction of motion of a cloud. *Exhibited by the* METEOROLOGICAL COUNCIL.

7. **Photo-Nephograph designed by Capt. Abney, F.R.S., for the registration of the velocity and direction of motion of Clouds.** (See *Reports of the Meteorological Council* for the years 1879 and 1881.)
Exhibited by the METEOROLOGICAL COUNCIL.

8. **Model showing manner in which the pair of Photo-Nephographs are mounted for use.** *Exhibited by the* METEOROLOGICAL COUNCIL.

9. **Camera for photographing Clouds and Lightning,** with a mirror of black glass attached. *Exhibited by* A. W. CLAYDEN, F.R.Met.Soc.

10. **Photographic Theodolite for measuring the height of Clouds.**
Exhibited by MM. L. TEISSERENC DE BORT AND G. RAYMOND.

11. **Slide Rule devised by Lieut.-Gen. Strachey, F.R.S., to facilitate the computation of Cloud heights and distances.** This scale is constructed for use with measurements of the azimuth and zenith distances of clouds made from either end of the base of 2,400 feet. It consists of four scales, the upper being that of log. sines, and the lowest that of log. numbers, the log. of 2,400 ft. coinciding with log. sin 90°. The upper slide is graduated with log. sines of small angles on the same scale, and has two index marks, one at 0°34′23″, the log. sin of which is 8·00000, and the other at 5°44′21″, the log. sin of which is 9·00000. The lower slide is graduated with log. tangents Z, the scale corresponding to that of the sines. To use the rule the index of the upper slide is set to the angle A on the upper scale; the index of the lower slide is then set to the angle A-B on the upper slide, and below it on the lower fixed scale will be found the distance in feet, while below the angle Z upon the lower slide will be found the height of the cloud in feet.
Exhibited by the METEOROLOGICAL COUNCIL.

12. **Instrument designed by Sir G. G. Stokes, Bart., F.R.S., for determining the height, and rate, and direction of motion, of Clouds from photographs.** Photographs of a cloud are taken simultaneously by two cameras placed at either end of a measured base, a second set being taken after a given interval, say of 1 or 2 minutes. A print of one of the four negatives thus obtained is placed upon a sheet of paper, upon which cross lines have been ruled to allow of the picture being properly adjusted, and with a needle a prick is made through the position of the point of the cloud which has been selected for measurement: this process is repeated for each of the remaining pictures of the set. The sheet of paper, which now contains four holes, is placed over the square aperture in the diaphragm of the instrument, which is fixed at a distance from the lens at the end equal to the focal length of the camera lens. Another sheet of paper is then placed on the moveable board beyond the diaphragm which, by means of the divided arc attached to it, is set to the zenith distance of the cameras at the time the

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photographs were taken. The instrument being now placed so that a strong light is allowed to pass through the lens on to the diaphragm, four spots of light will be formed upon the paper on the board, which being joined will form a parallelogram, two opposite sides of which will give the *drift* of the cloud on the same scale as the other two sides represent the distance between the two cameras. The *direction* of the drift is readily obtained from the position of the one pair of sides relatively to the other, the latter being parallel to the measured base, the bearings of which are of course known. The product of the distance from the lens to the board and the length of the measured base in feet, divided by the length of the side of the parallelogram parallel to the base, gives at once the *height* of the cloud in feet.

Exhibited by the METEOROLOGICAL COUNCIL.

13. **Apparatus for ascertaining the height, and direction, and rate of motion of Clouds from photographs; devised by the late G. M. Whipple, B.Sc.** In this case simultaneous photographs of a cloud are taken by two cameras at either end of a measured base, and fixed in such a way that their optical axes point to the zenith. The dark slides of the cameras carry a pair of fiducial lines at right angles to each other, and adjusted so that one of the lines shall be parallel to the measured base, and these lines are reproduced upon the cloud photographs. The two negatives are superimposed in the sliding frames of the apparatus, which are then moved till the images of the cloud exactly coincide, when the parallax will be given by a line joining the intersections of the fiducial lines. The parallax having been measured by a pair of compasses, the *height* of the cloud can be at once determined by means of the curve *A* (exhibited No. 107). A similar operation is then performed with one of the same negatives, and a second taken in the same camera after the lapse of, say, one minute. The pictures having been made to coincide as before, the distance between the intersections of the fiducial lines will now indicate the *drift* of the cloud. The *direction* of the drift is indicated by the position of the line joining the two intersections relatively to the fiducial line parallel to the base. The *velocity* of the drift, or in other words the rate of motion of the cloud, is found graphically by means of the diagram B exhibited.

Exhibited by the METEOROLOGICAL COUNCIL.

14. **Appliance for estimating the height of Clouds of the Roll Cumulus type by means of their perspective effect.**

Exhibited by R. INWARDS, Pres.R.Met.Soc.

THERMOMETERS.

15. **Hypsometer for measuring mountain heights by the temperature of the vapour of boiling water.** *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

16. **Thermometer for Balloon observations.** A mercurial thermometer with very long cylindrical bulb in mahogany frame.

Exhibited by the METEOROLOGICAL COUNCIL.

17. **Alarm Thermometer by MM. Richard Frères.** This consists of a flat but slightly curved tube filled with liquid, the bottom end of which is fixed. To the upper end is attached a rod which moves an index hand in front of a dial, thus indicating the temperature. There are also two adjustable indices which can be set to any desired temperatures, so that when the indicating hand touches these, electric contact is made and a bell set ringing. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

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HYGROMETERS, EVAPORATORS, &c.

18. **Dew Point Calculator.** This consists of a dry and wet bulb thermometer, to each of which is attached a fixed and adjustable index connected with a pointer for showing on an adjoining scale the temperature of the dew point. *Exhibited by* J. F. SPONG, M.R.C.S.

19. **Inverted Tube Hygrometer.** This arrangement dispenses with the water vessel beneath the wet bulb thermometer; and also registers the amount evaporated from the surface of the bulb, from which the amount of evaporation per square foot for small surfaces can be obtained.
Exhibited by H. HAINSBY.

20. **Vapour Condensor.** This indicates the hygrometric condition of the air by the amount of condensation of vapour on the surface of the plate at the time of observation; also the probable rainfall for the following 24 hours, the face of the plate becoming wet in proportion to the amount of moisture prevailing at the time. *Exhibited by* H. HAINSBY.

21. **Compensating Siphon Evaporator for large water surfaces.** This apparatus being connected by a pipe with any sized tank desired, enables an observer to see by the siphon gauge the rate of evaporation from the large tank, and also the amount of evaporation, without any alteration in the volume of water in the tank. It can also be used as a rain gauge on a large scale if required. *Exhibited by* H. HAINSBY.

22. **Louvred Glass Evaporator.** This evaporator is constructed entirely of glass, in order to permit access of the sun's rays to influence the evaporation of the water contained therein. It is surmounted by a louvred glass hood to protect the water from rain, birds, &c., but this allows the free circulation of air through it. The contents can be measured by the usual means.
Exhibited by DR. W. G. BLACK, F.R.Met.Soc.

MARINE INSTRUMENTS.

23. **Model of Bottle for collecting samples of sea water from moderate depths.** This instrument is intended for use where the sea-disturbance is so great as to make the action of slip water bottles uncertain. At either end of the cylindrical bottle is a tap, tubes from which terminate close together above the bottle, pointing upwards. The taps are closed by extending a spring and hooking the upper rod to the catch, and the instrument is let down to the required depth. A "Rung" messenger sent down the line relieves the catch and opens both taps, admitting water and allowing air to escape. As the two tubes are in the same horizontal plane there is no tendency for the water to change while the bottle is brought to the surface.
Exhibited by H. N. DICKSON, F.R.Met.Soc.

24. **Keating's Hydrometer.** *Exhibited by* J. J. HICKS, F.R.Met.Soc.

ANEMOMETERS.

25. **Dines's Pressure Tube Anemometer.** Recording pattern. (See *Quarterly Journal*, Vol. XVIII. p. 165).
Exhibited by R. W. MUNRO, F.R.Met.Soc.

26. **Dines's Pressure Tube Anemometer, indicating the velocity at sight and also registering the maximum.** (See *Quarterly Journal*, Vol. XIX. p. 16). *Exhibited by* R. W. MUNRO, F.R.Met.Soc.

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27. **Dines's Pressure and Velocity Gauge** for use with the Tube Anemometers. The instrument shows on the scale the greatest velocity that has occurred since it was last set by means of the level of the water in the glass tube. It is set by removing the plug and pouring water into the funnel at the top until the water begins to flow from the opening at the side. The plug is then replaced, and the quantity of water forced out by the wind leaves a record of the maximum force that has occurred. *Exhibited by* R. W. MUNRO, F.R.Met.Soc.

28. **Capell-Davis Anemometer for ascertaining velocities over 30 ft. per second.** This instrument is designed to test such high velocities as would endanger the Biram or Davis's self-timing Anemometer. The instrument is 4 ins. in diameter and reads to ten million feet.
Exhibited by Messrs. JOHN DAVIS & SON.

TRAVELLERS' INSTRUMENTS.

29. **Goad's Geodetic Altazimuth.** This is an adaptation of the Galton Pocket Altazimuth for use as a hand instrument in exploring work, as well as for surveys requiring the greatest precision either on the surface or in mines and other workings. In this instrument the compass box is so connected to the clinometer drum that it can either be folded flat against the end of the same, or turned to a position in which the axis of the compass is so mounted that it may be rotated about the axis of the clinometer, a circle graduated to correspond to the clinometer scale being provided to enable the compass to be adjusted to a horizontal position by reference to the reading of the clinometer.
Exhibited by L. P. CASELLA, F.R.Met.Soc.

30. **Universal Sun Dial** for any position north or south of the equator with 2½ in. divided circle. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

31. **Artificial Horizon** of parallel black glass, with level and adjusting screws.
Exhibited by L. P. CASELLA, F.R.Met.Soc.

32. **Artificial Horizon,** mounted on gimbals.
Exhibited by L. P. CASELLA, F.R.Met.Soc.

33. **Hicks's Circular Level,** with the fluid hermetically sealed.
Exhibited by J. J. HICKS, F.R.Met.Soc.

BAROMETERS.

34. **Bartrum's Open Scale Barometer.** *Exhibited by* J. J. HICKS, F.R.Met.Soc.

35. **Calendar's Compensating Open Scale Barometer.**
Exhibited by J. J. HICKS, F.R.Met.Soc.

SKETCHES AND PHOTOGRAPHS OF CLOUDS.

36. **Portrait of Luke Howard, F.R.S.** Born November 28th, 1772; died March 21st, 1864. Drawn by Bedford about 1843. (See frontispiece.)
Exhibited by W. D. HOWARD, F.R.Met.Soc.

37. **Clouds gathering for a Thunderstorm.** An original sketch by the late Luke Howard, F.R.S. "A sky full of specimens of the peculiar forms assumed by the clouds when gathering for a thunderstorm. (The dense

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clouds in front, though characteristic as forms, are not enough shrouded in a gloomy distance.) The Nimbus behind, on the left, is better placed, and shows crossed, as is at times the case, by a dense cirro-stratus. The Cirro-cumulus, next above, is highly characteristic in its structure; and the large dense Cirrus above belongs equally to approaching thunder. March 1849." *Exhibited by* W. D. HOWARD, F.R.Met.Soc.

38. **The Commencement of a Stratus.** An original sketch by the late Luke Howard, F.R.S. "This picture presents, mixed with the objects common to a landscape, the commencement of a Stratus, or evening mist, creeping, as it rises, through the valley, to become shortly a dense body of cloud, resting with a lever surface on the ground like a lake of water; and possibly, on the morrow, covering the country with a fog. Above, in the blue sky, are features of Cirrus. March 1849."
Exhibited by W. D. HOWARD, F.R.Met.Soc.

39. **Rough Models illustrating the Forms of Clouds.**
Exhibited by F. GASTER, F.R.Met.Soc.

40. **Cloud Photographs taken by Mons. Paul Garnier at the Observatory, Boulogne-sur-Seine, 1889.**
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

41. **Cloud Photographs taken at the Santis Observatory, Switzerland.**
Exhibited by PROF. A. RIGGENBACH-BURCKHARDT.

42. **Thunder Clouds, August 1st, 1890, taken from the Santis Observatory, Switzerland.** (See *Meteorologische Zeitschrift*, Band 8, 1891, p. 96.) *Exhibited by* PROF. A. RIGGENBACH-BURCKHARDT.

43. **Thunderstorm at Sydney, May 31st, 1892.** A series of six photographs taken by Mr. H. C. Russell, F.R.S., between 3.0 and 4.59 p.m.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

44. **Festooned Cumulus.** Two photographs showing part of a storm cloud which passed over Sydney, New South Wales, January 18th, 1893.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

45. **Clouds preceding a "Southerly Burster"** at Sydney, New South Wales, November 13th, 1893, 6 p.m. *Exhibited by* H. C. RUSSELL, F.R.S.

46. **The Cloud-Roll of the "Southerly Burster"** at Sydney, New South Wales, November 13th, 1893, 7 p.m. *Exhibited by* H. C. RUSSELL, F.R.S.

47. **Cloud Photographs.** *Exhibited by* DR. F. G. SMART, F.R.Met.Soc.

48. **Cloud Photographs taken at Paris.** *Exhibited by* MONS. A. ANGOT.

49. **Thunder Clouds.** Taken by Dr. F. Drewitt in Northamptonshire, July 1887. *Exhibited by the* ROYAL METEOROLOGICAL SOCIETY.

50. **Tornado Cloud, Jamestown, Dakota, June 6th, 1887.** Two photographs. The cloud funnel was 12 miles to the north.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

51. **Tornado Cloud.** Taken in the storm of June 22nd, 1888, showing the spiral-shaped funnel trailing at a considerable altitude in the air at the other side of a lake, New Hampshire, U.S.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

52. **Collection of the Cloud Photographs,** which are reproduced in Singer's *Cloud Atlas*, and which are arranged according to the classification proposed by the Hon. R. Abercromby and Dr. H. H. Hildebrandsson.
Exhibited by DR. K. SINGER.

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53. **Photographs of Cirrus and Cirro-cumulus Clouds.**
Exhibited by Mons. G. Raymond.

54. **Set of Cloud Photographs.** *Exhibited by* Dr. A. Sprung.

55. **Clouds taken at the Vatican Observatory, Rome,** under the direction of Padre F. Denza, by Signor Mannucci.
Exhibited by the British Association Committee on the Application of Photography to Meteorology.

56. **Cloud Photographs illustrating Capt. D. Wilson-Barker's proposed Cloud Nomenclature.**
Exhibited by Capt. D. Wilson-Barker, F.R.Met.Soc.

57. **Cloud types: Cirrus, Cumulus, and Cirro-stratus.**
Exhibited by Birt Acres.

58. **Clouds taken by reflection from a black glass Mirror,** on Mawson and Swan's Photo-mechanical plates.
Exhibited by A. W. Clayden, F.R.Met.Soc.

59. **Cloud Photographs.** Two frames. *Exhibited by the* Kew Committee.

60. **Three framed Photographs of Clouds.** *Exhibited by* L. Cohen.

61. **Frames containing Photographs of Cloud Subjects.**
Exhibited by Col. H. M. Saunders.

62. **Poey's Classification of Clouds.** *Exhibited by* G. J. Symons, F.R.S.

63. **Illustrations of Cloud-forms,** being first proofs from Capt. FitzRoy's *Voyage of the Beagle*, 1839.
Exhibited by the Meteorological Council.

64. **Representation of the Forms of Clouds,** given in Admiral FitzRoy's *Log Book*. *Exhibited by the* Meteorological Council.

65. **Sketches of Cloud Forms by the late Mrs. Toynbee.**
Exhibited by the Meteorological Council.

66. **Typical varieties of Clouds.** Illustrating the Rev. W. Clement Ley's Lecture on "Clouds and Weather Signs" in *Modern Meteorology*, 1879.
Exhibited by the Royal Meteorological Society.

67. **Drawing showing typical Forms of Clouds** with their names and usual height in the atmosphere, and a scale of feet and miles, with sketches of comparative heights of mountains, &c. for comparison.
Exhibited by R. Inwards, Pres.R.Met.Soc.

68. **Plate showing method of measuring Heights of Cloud.** (From J. F. Glöckner's *De Pondere Nubium*, 1722).
Exhibited by G. J. Symons, F.R.S.

69. **Illustrations of Cloud-forms.** From *On the Modifications of Clouds, &c.*, by Luke Howard. First edition, 1803.
Exhibited by G. J. Symons, F.R.S.

70. **Hellmann's "Neudrucke von Schriften und Karten uber Meteorologie und Erdmagnetismus."** No. 3. Containing reprint of Luke Howard's memoir "On the Modifications of Clouds," 1803, with facsimiles of the three plates. *Exhibited by* Dr. G. Hellmann.

71. **Illustrations of Cloud-forms.** From *Researches about Atmospheric Phænomena*. By T. Forster. Third edition. 1823.
Exhibited by G. J. Symons, F.R.S.

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72. **Illustrations of Cloud-forms.** From *Meteorology*. By G. Harvey, F.R.S. *Encyclopædia Metropolitana*. 1834.
Exhibited by G. J. SYMONS, F.R.S.

73. **Illustrations of Primary and Secondary Cloud-forms,** from Maury's *Sailing Directions*, Eighth edition, 1859.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

74. **Illustrations of Cloud-forms.** From *Essay on the Modifications of Clouds*, by Luke Howard, F.R.S. Third edition, 1865.
Exhibited by G. J. SYMONS, F.R.S.

75. **Illustrations of Cloud-forms.** From *Clouds, their Forms and Combinations*. By Elijah Walton. Third edition, 1873.
Exhibited by the METEOROLOGICAL COUNCIL.

76. **Illustrations of Cloud-forms.** From "Atlas donnant les principales formes des nuages avec un résumé de leur classification;" par P. Weilbach. 1881. *Annuaire de l'Institut Météorologique du Danemark*). *Exhibited by* G. J. SYMONS, F.R.S.

77. **Illustrations of Cloud-forms.** From *Le Monde Physique*: par A. A. Guillemin. Tome V. La Meteorologie. 1885.
Exhibited by G. J. SYMONS, F.R.S.

78. **"Measurement of Cloud Heights and Velocities at the Blue Hill Meteorological Observatory,"** being Part III. of Vol. XXX. *Annals Harvard College Observatory*. *Exhibited by* A. L. ROTCH, F.R.Met.Soc.

79. **Singer's "Wolkentafeln."** *Exhibited by* DR. K. SINGER.

SKETCHES AND PHOTOGRAPHS OF METEOROLOGICAL PHENOMENA.

80. **Lightning, June 28th, 1892.** Two enlargements of photographs taken by Mr. G. Corden at Croydon, 8.45 to 9 p.m.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

81. **Lightning, June 28th, 1892.** Enlargement of photograph taken by Mr. R. H. Pickel at Bexley at 10.30 p.m.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

82. **Lightning at Sydney, December 7th, 1892.** Two photographs taken by Mr. H. C. Russell, F.R.S., at the Observatory. The point at which the flash struck the water was 2,000 ft. from the camera.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

83. **Cedar Tree struck by Lightning, July 18th, 1892,** at Tyntesfield Park, Wraxall, near Bristol.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

84. **Frost Fronds on Window.**
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

85. **Site of Waterspouts at Langtoft, near Driffield, June 9th, 1888, and July 3rd, 1892.** (See *Quarterly Journal of the Royal Meteorological Society*, Vol. XIX., p. 1.)
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

86. **After the Flood at Langtoft, near Driffield, July 3rd, 1892.** (Two photographs.) *Exhibited by the* ROYAL METEOROLOGICAL SOCIETY.

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87. **Hailstones (actual size) which fell at Richmond, Yorkshire, July 8th, 1893.** (Two photographs.) Some of the hailstones were more than 2 ins. in diameter.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

88. **Damage by Hail to Conservatory in the Bog Valley Gardens, Harrogate, July 8th, 1893.**
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

89. **Old Sulphur Well, Harrogate.** This photograph, which was taken in November 1893, shows the marks made upon the lead roof by the hailstones that fell during the terrific thunderstorm on July 8th.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

90. **Iron Roofing perforated by Hail,** October 13th, 1892, at Tulcumbah, New South Wales.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

91. **Atmospheric Phenomena** consisting of coloured Solar Halos, Parhelia, a white Circle around the sun, and an Anthelion, as seen at Gosport, March 29th, 1848. Drawn by Mr. J. H. Maverley.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

92. **Solar Halos seen at Weymouth, April 28th, 1883.** Coloured sketch by Mr. J. T. See. *Exhibited by* W. MARRIOTT, F.R.Met.Soc.

93. **Photograph of Rainbow.** *Exhibited by* REV. F. C. LAMBERT.

94. **Snow Scene, Tunbridge Wells, April. 1892.**
Exhibited by DR. F. G. SMART, F.R.Met.Soc.

95. **Photograph of Fog on January 12th, 1888,** taken from the top of the Worcestershire Beacon (1,390 ft. above sea-level), about 700 ft. above the general level of the fog which covered the whole of the surrounding country. Above the fog there was bright sunshine and clear sky.
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

96. **Twilight and After-Glow effects at Chelsea, November 26th, 1883.** (See *Report of the Krakatoa Committee of the Royal Society*, 1888).
Exhibited by H. S. WALLIS, F.R.Met.Soc.

97. **Diagrams illustrating Krakatoa Volcanic Dust** collected 1,000 miles from the place of eruption. Enlarged 10,000 diameters.
Exhibited by W. F. STANLEY, F.R.Met.Soc.

98. **"The Daily Graphic." Drawings used to illustrate the Weather Forecasts.** *Exhibited by* C. HARDING, F.R.Met.Soc.

PHOTOGRAPHS AND DIAGRAMS OF INSTRUMENTS.

99. **Daguerreotype showing the collection of apparatus for Mr. Welsh's Balloon Ascents at Vauxhall Gardens, July 1852,** with likenesses of several members of the Kew Committee of that date.
Exhibited by the KEW COMMITTEE.

100. **Photographs of Mr. J. Glaisher, F.R.S., and Mr. H. Coxwell in the car of a Balloon, with meteorological instruments in position.**
Exhibited by G. J. SYMONS, F.R.S.

101. **Photograph showing the arrangement of the Meteorological Instruments** adopted for the ascents of the free balloon belonging to the "Deutscher Verein zur Forderung der Luftschiffahrt."
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

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102. **Cloud Equatorial constructed by Dr. Nils Ekholm, Hon. Mem. R. Met. Soc.**
Exhibited by the ROYAL METEOROLOGICAL SOCIETY.

103. **Photograph of Theodolite used in the determination of Cloud altitudes** at the Blue Hill Observatory, Mass., U.S.A.
Exhibited by A. L. ROTCH, F.R.Met.Soc.

104. **Photograph of Plotting Machine** for graphical solution of data obtained with the above Theodolite (No. 103).
Exhibited by A. L. ROTCH, F.R.Met.Soc.

105. **Photograph of Pole Star Recorder** in use at the Blue Hill Observatory for recording cloudiness at night.
Exhibited by A. L. ROTCH, F.R.Met.Soc.

106. **Two Photographs of "Trails" by Pole Star Recorder.**
Exhibited by A. L. ROTCH, F.R.Met.Soc.

107. **Diagrams designed by Lieut.-Gen. Strachey, F.R.S., to facilitate the calculation of the height and motions of Clouds from photographs.** Diagram A is arranged to give the *height* of the cloud, the heights being indicated by the abscissæ on a scale in which the length of the base between the two cameras is equal to the focal length of the camera lens. The parallax obtained in the way explained under Exhibit No. 13 is measured on the ordinates of the curve, and the corresponding height is at once read off below.

Diagram B gives the *rate of motion* of the cloud. The line A B represents the measured base between the two cameras upon the same scale as is used to represent one mile upon the larger diagram of proportional velocities. The drift obtained from the negatives, in the manner explained under Exhibit No. 13 is marked off upon the lines A C and B D measuring from A B, and the parallax is marked off upon the line A B, measuring from A; a line is then drawn from the point on A C through that on A B to the line B D, and the distance from the point previously marked off on B D to the extremity of this line is taken off and measured on the diagram of relative velocities, upon the vertical line corresponding to the interval in seconds which had elapsed between the taking of the two photographs.
Exhibited by the METEOROLOGICAL COUNCIL.

108. **Records of Velocity of the Wind by Dines's Pressure Tube Anemometer** at Oxshott, Surrey, December 12th and 13th, 1893; February 7th, 11th; and March 2nd and 27th, 1894.
Exhibited by W. H. DINES, F.R.Met.Soc.

109. **Drawing of a suggested form of Barometer** designed to give readings already corrected for capacity, capillarity, temperature and height above sea level. The temperature correction is obtained by reading the thermometer which has its bulb immersed in the mercury of the cistern. The horizontal screw head at the top of the instrument is then turned until the pointer on the horizontal scale points to the temperature. This has the effect of depressing or raising the vernier by means of an inclined plane so as to deduct or add the proper correction for temperature. The inclination of the plane supporting the vernier changes with its rise on the scale by means of diagonal slots on the brass frame of the instrument. These can be adjusted when the instrument is made.

The capacity correction is made by a milled head at the bottom or cistern end of the instrument, and a glass plunger is caused to immerse itself in the mercury until it just brings the level of the same to the ivory point which is fixed above its surface. The capillarity corection is not needed with so large a bore. The correction for heigt above sea level is provided by shortening the instrument by means of the screws in the middle of its height, and, of course, the temperature adjustment must be made to correspond when the instrument is first adjusted for its station. *Exhibited by* R. INWARDS, Pres.R.Met.Soc.

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110. **Chart for reducing readings of Metallic Barometers** to the temperature of 32°; by Mr. E. H. Griffiths.
Exhibited by J. J. Hicks, F.R.Met.Soc

LANTERN SLIDES AND TRANSPARENCIES.

111. **Clouds taken mostly at the Santis Observatory, Switzerland.** (26 Slides.) *Exhibited by* Prof. A. Riggenbach-Burckhardt.

112. **Clouds taken by reflection from a black glass Mirror.** (24 Slides.) *Exhibited by* A. W. Clayden, F.R.Met.Soc.

113. **Slides illustrating Capt. D. Wilson-Barker's proposed Cloud Nomenclature.** *Exhibited by* Capt. D. Wilson-Barker, F.R.Met.Soc.

114. **Clouds from Photographs taken by Mons. Paul Garnier,** at the Observatory, Boulogne-sur-Seine, 1889.
Exhibited by W. Marriott, F.R.Met.Soc.

115. **Clouds comprising Cirrus, Cirro-cumulus, Cumulus and Stratus.**
Exhibited by Birt Acres.

116. **Slides and Transparencies showing the movements of Cumulus and Cirrus Clouds at intervals of 30 seconds.** *Exhibited by* Birt Acres.

117. **Slides of Clouds.** Most of these are Upper Clouds with a few Cumulus.
Exhibited by A. D. Hall.

118. **Slides of Clouds.**
Exhibited by Rear-Admiral J. P. Maclear, F.R.Met.Soc.

119. **Clouds** (4 slides). *Exhibited by* A. Stroh.

120. **Clouds** (3 slides). *Exhibited by* H. E. Davis.

121. **Clouds** (2 slides). *Exhibited by* L. Cohen.

122. **Clouds** (3 slides). *Exhibited by* T. C. White.

123. **Clouds** (6 slides). *Exhibited by the* Sciopticon Co.

124. **Aurora Borealis** (2 slides). *Exhibited by the* Sciopticon Co.

125. **Festooned Cumulus at Sydney, New South Wales, January 18th, 1893.** *Exhibited by* W. Marriott, F.R.Met.Soc.

126. **Hailstones which fell at Richmond, Yorkshire, July 8th, 1893.** Taken by Mr. J. H. Metcalfe.
Exhibited by the Royal Meteorological Society.

127. **Man's Hat damaged by Hailstones at Richmond, Yorkshire, July 8th, 1893.** *Exhibited by* W. Marriott, F.R.Met.Soc.

128. **Iron Roofing perforated by Hail** at Tulcumbah, New South Wales, October 13th, 1892. *Exhibited by the* Royal Meteorological Society.

129. **Lightning Flashes, at Croydon, June 28th, 1892.** Taken by Mr. G. Corden. *Exhibited by the* Royal Meteorological Society.

130. **Lightning Flashes, June 28th, 1892.** Taken at Bexley by Mr. R. H. Pickel. *Exhibited by the* Royal Meteorological Society.

131. **Trees struck by Lightning in the neighbourhood of Bristol, 1892.**
Exhibited by the Royal Meteorological Society.

132. **Hear Frost on Grass;** taken by Rev. J. M. Coates, at Welton-le-Wold, Lincolnshire. *Exhibited by* W. Marriott, F.R.Met.Soc.

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133. **Slides of Clouds.** *Exhibited by the* KEW COMMITTEE.

134. **Two Slides showing the Cloud Camera in position.** *Exhibited by the* KEW COMMITTEE.

135. **Slides of Clouds.** *Exhibited by* F. GASTER, F.R.Met.Soc.

136. **Slides of Clouds.** *Exhibited by* COL. H. M. SAUNDERS.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

March 21st, 1894.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

HUGH CHARLES KIDDLE, Public School, Walbundrie, New South Wales; and SIDNEY RICHARD LOWCOCK, Assoc.M.Inst.C.E., 85 Waterloo Street, Birmingham, were balloted for and duly elected Fellows of the Society.

It was announced that the Society, in conjunction with the Sanitary Institute, had arranged for a course of six Lectures on "Meteorology in relation to Hygiene," to be given at the Parkes Museum, Margaret Street, W., as follows:—

April 23rd. Instruments and Observations and their Representation. G. J. SYMONS, F.R.S.

„ 26th. Temperature of Air, Soil and Water. Dr. H. R. MILL, F.R.S.E.

„ 30th. Barometric Conditions and Air Movements. R. H. SCOTT, M.A., F.R.S.

May 3rd. Moisture, its Determination and Measurement. W. MARRIOTT, F.R.Met.Soc.

„ 7th. Climate in Relation to Health, and Geographical Distribution of Disease. C. THEODORE WILLIAMS, M.A., M.D., F.R.C.P.

„ 10th. Fog, Clouds and Sunshine. F. GASTER, F.R.Met.Soc.

The fee for the course would be half-a-guinea. Fellows of the Society would be admitted without payment.

The following communications were read:—

"RELATION BETWEEN THE MEAN QUARTERLY TEMPERATURE AND THE DEATH RATE." By W. H. DINES, B.A., F.R.Met.Soc. (p. 178.)

"DURATION AND LATERAL EXTENT OF GUSTS OF WIND, AND THE MEASUREMENT OF THEIR INTENSITY." By W. H. DINES, B.A., F.R.Met.Soc. (p. 180.)

"ON THE CALCULATION OF PHOTOGRAPHIC CLOUD MEASUREMENTS." By Dr. K. G. OLSSON. (p. 187.)

Mr. R. H. SCOTT, F.R.S., read the following

"NOTE ON UNUSUALLY SUDDEN BAROMETRICAL OSCILLATIONS AND HIGH WIND VELOCITY IN THE BRITISH ISLES IN FEBRUARY 1894."

THE storm which passed over the North of Scotland on the night of February 23rd-24th, was not marked by any very high wind velocity at our station at Deerness in the Orkneys, as will be seen from the figures in the left-hand portion of Table I., giving the hourly velocities and direction for the two days.

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The behaviour of the barometer at the three stations on the north-west and north coasts was, however, most remarkable, as will be seen from Table II.

TABLE I.

Hour.	Deerness. February 1894. 23rd. Velocity.	Deerness. February 1894. 23rd. Direction.	Deerness. February 1894. 24th. Velocity.	Deerness. February 1894. 24th. Direction.	Fleetwood. February 1894. 11th. Velocity.	Fleetwood. February 1894. 11th. Direction.	Fleetwood. February 1894. 12th. Velocity.	Fleetwood. February 1894. 12th. Direction.
	Miles.		Miles.		Miles.		Miles.	
1 a.m.	30	SW by S	38	W by N	7	N by E	81	W by S
2 „	32	WSW	36	W	3	NNE	80	„
3 „	35	SW by S	36	WSW	3	„	86	W
4 „	27	SW	37	W by S	3	„	85	„
5 „	21	SW by W	34	WSW	5	„	90	W by N
6 „	21	SW by S	32	W by S	24	W by S	83	WNW
7 „	26	SSW	29	WSW	38	SW by W	80	„
8 „	32	„	32	W by S	42	SW	77	„
9 „	32	„	25	„	47	„	61	W by N
10 „	35	„	38	WSW	49	„	65	„
11 „	35	„	24	W by S	49	„	62	WNW
Noon	34	„	39	WSW	50	„	65	„
1 p.m.	33	S by W	34	„	49	„	61	W by N
2 „	36	S by E	33	W	52	„	60	W
3 „	42	„	33	W by N	53	„	52	WNW
4 „	44	„	30	W	57	„	52	W by N
5 „	51	SSE	20	W by N	61	„	49	WNW
6 „	55	„	23	W	67	„	50	„
7 „	54	S by E	28	„	69	SW by S	52	„
8 „	40	„	29	„	70	„	46	„
9 „	58	WNW	29	W by S	65	SW	49	„
10 „	67	„	31	WNW	66	SW by W	47	„
11 „	50	„	26	W	77	W by S	41	„
Midnight	43	W by N	27	W	76	„	41	„

TABLE II.

February 23, 1894.	Malin Head. ins.	Stornoway. ins.	Sumburgh. ins.
6 a.m.	29·74	29·45	29·39
7 „	·70	·40	·39
8 „	·65	·38	·40
9 „	·56	·40	·39
10 „	·50	·35	·37
11 „	·42	·30	·32
Noon	·33	·22	·29
1 p.m.	·20	·14	·20
2 „	29·04	29·04	·03
3 „	28·95	28·93	29·05
4 „	29·02	·84	28·98
5 „	·03	·70	·92
5.30 p.m.		·50	
6 „	·18	·58	·85
7 „	·20	·75	·68
8 „	·21	·87	·50
9 „	·22	·92	·40
10 „	·23	28·95	·37
11 „	·24		·35
Midnight	29·25		28·50

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These figures show that at Stornoway the barometer fell 0·20 in., from 28·70 ins. to 28·50 ins., in the half hour from 5 to 5.30 p.m., a rate of fall rarely equalled in these islands.

Another matter also seems to merit notice, an actual run of an anemometer of 90 miles within an hour is rare. This velocity was overpassed for some hours at Deerness in the storm of November 18th-19th, 1893 (*Quarterly Journal*, Vol. XX. p. 48), and it was reached at Fleetwood at 5 a.m. February 12th, as will be seen from the right-hand portion of Table I.

Capt. D. WILSON-BARKER remarked that he had once seen the barometer rise ·06 in. in twenty minutes when in the neighbourhood of the Falkland Islands.

Mr. F. J. BRODIE said that the weather during December 1893 to February 1894 had been remarkable for the almost constant flow of large depressions along our extreme northern coasts, the barometer in the north of Scotland having been below 28·50 ins. on no fewer than five different occasions. The general effect was well shown in the difference between the mean pressures at Sumburgh Head and London; the normal differences being in December 0·28 in., in January 0·33 in., in February 0·21 in., and the average for the quarter 0·27 in.; whereas during the past winter the figures had been, December 0·51 in., January 0·40 in., February 0·62 in., and the average for the quarter 0·51 in. The mean gradient over the United Kingdom for the entire winter was therefore nearly twice as steep as usual, a fact which affords a simple key to the general mildness and storminess of the season, and to its partial immunity from fogs.

April 18th, 1894.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

BIRT ACRES, Clovelly Cottage, Barnet;
JOHN FARRAH, 8 Crescent Road, Harrogate; and
KAUFMANN ISRAEL MARKS, 174 Sutherland Avenue, Maida Vale, W.,
were balloted for and duly elected Fellows of the Society.

The following communication was read:—

"SOME PHENOMENA OF THE UPPER AIR." By RICHARD INWARDS, F.R.A.S., President. (p. 199.)

On the motion of Mr. G. CHATTERTON, seconded by Mr. S. W. SILVER, the thanks of the Society were given to the Exhibitors for the loan of their instruments, &c.

The meeting was then adjourned for a short time in order to allow the Fellows and their friends an opportunity of inspecting the Exhibition of Instruments, Drawings, and Photographs relating to the Representation and Measurement of Clouds, which had been arranged in the rooms of the Institution of Civil Engineers. (p. 217.)

At 9.30 p.m. a Lantern Display was given of slides illustrating various meteorological phenomena, Mr. W. MARRIOTT giving a description of the various pictures.

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CORRESPONDENCE AND NOTES.

Whirlwinds on May 26th, 1894.—The following accounts of two whirlwinds are taken from the *Times*:—

"A WHIRLWIND IN HEREFORDSHIRE.—The Rev. H. C. Sturges writes to us from Bodenham Vicarage, Leominster:—'If a whirlwind be a violent movement of the atmosphere in a circular direction about an axis, we certainly had one in this village on Saturday, May 26th, between 1 and 2 p.m. Two dense thunder clouds were seen approaching with their separate storms at about 1.30 p.m., the one from the north-west the other from the north-east. These appeared to meet n the centre of this village, which is in one of the Lugg valleys, eight miles north of Hereford. Within a radius of about 300 yards there was such a violent movement of the atmosphere in a circular direction that trees were cut off at the stem, huge branches off the elm trees were carried 50 yards or more, and tiling was lifted off the buildings. At the same time sheets of hailstones were hurled against the windows from all points of the compass. Beyond the radius of the storm vortex the weather was calm and bright, so that our friends three-quarters of a mile off to the west, who witnessed us enveloped in an inky blackness, suffered nothing. A pond in the village is almost entirely choked with fallen timber, the trees having fallen against each other. Is it not a most unusual thing in this country for the area of a storm of wind of such violence to be so exceedingly limited in extent? I ought to add that some wind and a great deal of hail was experienced to the east of us, but not wind sufficient to break a branch off a tree.'"

"THE WHIRLWIND.—Mr. Richard P. Dansey, of Ludlow, writes to us:—'Having seen in your columns a letter from the Rev. H. C. Sturges, describing a whirlwind near Leominster on May 26th, I trust you will be able to find space for an account of another cyclone, or whirlwind, which occurred near Ludlow on the same date, and at approximately the same time, the description of which agrees in every particular with that given by your correspondent. About 1 p.m. on Saturday the 26th, a very heavy storm broke over the Clees (whose highest point rises to 1,805 ft. above the sea), accompanied with incessant thunder and lightning. In five minutes, or less, these hills were quite white and completely covered with snow down to about 1,000 ft. high, while the lightning all the time was most vivid and the thunder very loud. A few minutes afterwards a sort of secondary storm appeared to be forming in the north about a mile and a half away. One could see sheets of hail sweeping out of the dark clouds, while clouds of dust were swept across the fields which evidently indicated a tremendous wind, as, indeed, proved to be the case. The path of the cyclone, for such indeed it was, seemed about 300 yards wide, and it advanced towards us with tremendous rapidity, and even as it came we could trace its passage by the trees and branches which could be seen falling in the distance as the cyclone approached. Suddenly it reached us together with a downpour of huge hailstones and lumps of ice. The centre or vortex of the whirlwind seemed to pass directly over our house, and swept everything before it. We saw three trees fall in the garden—including a magnificent fir, 80 ft. in height—at the same moment and within 60 yards of each other, while others were bent double; a roof was lifted bodily off a French barn and carried over fields and hedges a distance of 200 yards; big, heavy glass lights were blown off cucumber frames; a large garden bench was whirled through the air and deposited upside down: hens were caught off their feet and sent literally flying through the air, and the air was filled with branches and *débris* to such a degree that, coupled with blinding snow, which had succeeded the hail, and was whirling round and round, one could not see more than 80 yards. The wind and storm had all passed in a very few minutes, the extreme height of the cyclone being limited to about 30 seconds. In every field could be seen oaks or chestnuts or other prostrate trees, and in places, also, the snow still lay where it had drifted. The whirlwind seemed to go up into the air about half-a-mile beyond us, coming down to the ground again about 1½ mile to our south, where it again wrought enormous destruction, though outside its narrow path not a tree was touched. We all thought the gale of Sunday, February 11th, severe, even

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though it only blew down half-a-dozen trees in our vicinity, but it was merely a gentle breeze compared with the awful intensity of the cyclone experienced on the 26th, which must have uprooted hundreds of trees in its path, narrow though it was.'"

Electric Phenomena during Thunderstorms.—In a letter to the *Standard* of May 31st, Mr. C. S. Du Riche Preller, writing from Baden, Switzerland, said:—"Some exciting and horribly beautiful, but also very dangerous, electric phenomena were observed in the picturesque Canton of St. Gall, on the evening of the 25th inst., during a thunderstorm of extraordinary violence, accompanied by a deluge of rain. The large 'village' of Gossau, about seven miles from the town of St. Gall, derives its electric supply for lighting and motive power for industrial purposes from a hydro-electrical central station, situated at a distance of eight miles, by a high tension transmission, with transformer stations in the village. The thunderstorm, accompanied by violent lightning discharges, passed over the place at 5 p.m., and then, driven back by a change of wind, returned, and lasted for several hours. Soon after 5 p.m. all the electric lights went out spontaneously, but the place was illuminated by violent sparks and flashes, which were emitted by the overhead wire system, and ran along the conductors. These phenomena reached their height at the principal transformer station, close to an hotel; for here the high pressure current escaped from the conductors to earth—viz. the ground saturated with rain—the effect being a succession of flashes or continuous blaze, which so endangered the building that the fire brigade had to be called out to protect it. These phenomena continued for several hours, till the electric supply was cut off at the central station, a special messenger on horseback having been despatched thither, for, wonderful to relate, the installation was as yet without telephonic communication. The lightning struck several houses in the village, though without doing harm; but a young man of powerful build, and of local position and great promise—for he was to have been elected Mayor on the very next day—inadvertently touched one of the electric cables, and was instantly killed. The inhabitants of the place might have been spared the terror of these phenomena, and probably no human life would have been lost, if the electric supply had been cut off during the altogether exceptional thunderstorm, as should always be done—and in the United States is done on some electric tramways—in districts visited by violent atmospheric discharges, and where overhead wires are used. Only last summer I witnessed a similar occurrence on the Mont Salève electric railway, near Geneva, where the lightning struck the feed conductor of the line, and thence found its way along the transmission cables to the central station, fully two miles distant, where it passed through the lightning arrester and burnt out one of the huge 1,000 horse-power dynamos. In this case, too, the lightning discharge was only the indirect cause, the direct cause being that the dynamo was running at the time, viz. that the current followed the discharge through the not quite perfect lightning arrester, and 'short-circuited' the dynamo."

Remarkable Flash of Lightning.—Herr O. Hoppe, in a paper "Oberirdische und unterirdische Wirkungen eines Blitzstrahles," which appeared in *Leopoldina*, Vol. XXIX., 1893, gives an account of a very remarkable flash of lightning which occurred on July 20th, 1881, near the town of Clausthal in the Hartz. The house struck was not situated in an exposed position, a church near it, but on a hill above it, escaped. Dr. Hoppe accounts for this by the circumstance that the house struck was standing in a damp, good conducting soil. He remarks that the joists of the house, of dry pine, were torn to splinters, but not set on fire; but where the lightning found nails in damp wood, the ends of the nails were fused and the wood caught fire. From this Dr. Hoppe concludes that iron nails or fastenings should not be used in roof timbers. The residents in the house were sleeping on feather beds, and were all uninjured. The experience of various miners at the level of 1,000 fathoms is given, as tendered in evidence before a commission of inquiry. They evidently felt the same flash as wrecked the house. The paper is worth notice for those who are engaged in lightning rod work.

Evaporation at Kimberley, South Africa.—Mr. R. H. Twigg, M.Inst.C.E., has favoured us with the monthly evaporation at the Kimberley Waterworks,

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South Africa, for the three years 1891-1893. The gauge is of wrought iron, 4 feet cube, buried in the ground to within 1 inch of the top; the level of the water inside is kept 2 or 3 inches below the top to allow for the heaviest showers. The gauge is read every day to ·001 inch by means of Twigg's hook gauge.

	1891. ins.	1892. ins.	1893. ins.
January	10·30	11·95	10·34
February	8·59	11·29	10·00
March	6·30	7·51	9·14
April	5·08	6·43	7·79
May	5·05	5·97	6·98
June	3·68	4·00	5·10
July	4·11	5·18	4·68
August	5·30	6·85	6·16
September	8·27	8·33	8·09
October	10·46	8·88	11·00
November	9·08	12·18	10·57
December	10·46	15·84	11·47
Year ...	86·68	104·41	101·32

Drought on the Coast of East Africa.—Mr. W. B. Cracknall, of Zanzibar, in a despatch to the Colonial Secretary, dated May 3rd, 1894, says :—"I have the honour to inform your Lordship that on the coast of East Africa, extending from Mozambique right through the German coast, there has been almost a total absence of the rain usually experienced at this season. In the Island of Zanzibar the rainfall for this year is, up to date, 12·82 ins., in contrast to 34·79 ins. registered up to April 30th last year.

"The South-west wind, which should be blowing strong and fresh, is gentle and variable, and the abnormal heat of the last few months has but slightly abated.

"Fears are entertained of a famine on the coast; and already I am informed the greatest scarcity of food prevails, while the price of rice in the Zanzibar bazaars is much augmented, and most probably the rainfall in the territory of the Imperial British East Africa Company will be irregular and scanty.

"I have troubled your Lordship with this despatch, as it is likely that this state of things may have some relation to the coming South-west monsoon of the Indian Empire."

Rainfall at Aburi, West Africa.—The following are the monthly amounts of rainfall for the three years 1891-93, at the Botanical station, Aburi, on the Gold Coast. The station is 1,400 feet above sea level, and 26 miles from the coast.

	1891. ins.	1892. ins.	1893. ins.
January	2·33	1·59	2·66
February	3·41	1·62	2·98
March	3·98	2·98	5·01
April	6·22	6·35	8·32
May	6·84	9·94	8·02
June	20·03	3 34	2·66
July	3·42	—	8·38
August	·37	·61	9·77
September	·37	—	4·14
October	1·86	9·75	8·92
November	3·80	3·69	3·40
December	2·81	2·84	2·48
Year ..	55·44	42·66	66·74

At Accra, on the coast, the rainfall in 1893 was 30·38 ins.

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RECENT PUBLICATIONS.

Aero-Therapeutics, or the Treatment of Lung Diseases by Climate. By CHARLES THEODORE WILLIAMS, M.A., M.D., F.R.C.P. 8vo. 1894. 187 pp. and plate.

This work comprises the Lumleian Lectures for 1893, which Dr. Williams delivered before the Royal College of Physicians. The object of the author has been to sketch a scientific system of Aero-therapeutics based on the combination of modern meteorology with clinical experience, each element of climate being duly considered in its bearing on health and disease. The first lecture is devoted to the factors and elements of climate; the second lecture is devoted to temperature and moisture; and in the third lecture the author deals with barometric pressure in its relation to health and disease. Dr. Williams also reproduces the address on the climate of Colorado, which he delivered before the Royal Meteorological Society on January 18th, 1893.

American Meteorological Journal. January-June 1894. 8vo.

The January No. contains several papers prepared for the Chicago Congress of Meteorology, viz.—1. History of the Weather Map: by M. W. Harrington (3 pp.). Eighteen current daily Weather Maps are now issued by the various national Weather Services. 2. The Meteorological work of the Medical Department of the U.S. Army: by Major C. Smart (2 pp.). 3. The Meteorological work of the Smithsonian Institution: by the Secretary (2 pp.). 4. Early individual observers in the United States: by A. J. Henry (2 pp.). 5. Storms of the North Atlantic: by E. Hayden (2 pp.). 6. The creation of Meteorological observatories upon the islands scattered over the ocean and connected with a continent by cable: by the Prince of Monaco (2 pp.).—Among the other contributions are:—The recurrence of hurricanes in the solar magnetic 26·68 day period: by Prof. F. H. Bigelow (4 pp.).—A Cloud-burst in Arizona: by J. D. Parker (4 pp.).—Recent foreign studies of Thunderstorms, No. IV.: by R. de C. Ward (9 pp.). The author in this paper gives a summary of the thunderstorm work carried on in Italy since 1882.—Certain climatic features of Maryland: by W. B. Clark (3 pp.).—Ten miles above the earth: by Prof. H. A. Hazen (5 pp.).—Measurement of the seasons: by H. Gawthrop (2 pp. and plate).—The Climate of Louisiana: by R. E. Kerkham (3 pp.).—A new series of isabnormal temperature charts, based on Buchan's isothermal charts: by S. F. Batchelder (24 pp.).—Storms of the Gulf of Mexico and their prediction: by W. D. Stearns (8 pp.).—A new chart of equal annual ranges of temperature: by J. L. S. Connolly (2 pp.).—Meteorology and Geodesy: by Prof. Cleveland Abbe (5 pp.).—The maximum precipitation of south-western North Carolina, particularly on the southern and eastern slopes of the Blue Ridge: by A. J. Henry (4 pp.).—The sea breeze at Boothbay Harbour, Maine: by G. B. Magrath (5 pp.).—The Texan Monsoons: by M. W. Harrington (13 pp.).—The marine Nephoscope and its usefulness to the navigator: by Prof. Cleveland Abbe (10 pp.).—The Pole Star Recorder: by S. P. Fergusson (3 pp.).

Annuaire de la Société Météorologique de France. Tome XLI., July-November 1893. 4to.

The principal articles are:—Sur la prévision du temps et sur l'enchaînement des situations atmosphériques: par P. Garrigou-Lagrange (28 pp. and 2 plates).—Des Nuages et de leur rôle dans la production des hydrométéorites: par C. Ritter (36 pp.). This is an elaborate attempt to explain the formation of clouds, especially of *cumuli*, by means of the phenomena developed when drops of ink or any other coloured fluid are very gently introduced into water. The author gives diagrams showing how the drops bifurcate and bifurcate again and again, giving an appearance like a candelabrum. The paper is divided as follows:—1. Generalities on the natural and mechanical properties of the surface of liquids. 2. The action of the epidermis when capillary veins and sheets of water flow into the air. 3. Action of the dermis when drops, veins, or sheets of certain liquids flow into water mists and liquid clouds. 4. Action of the atmodermes in the escape into the air of smoke and vapour fogs and "pulviscular" clouds. 5. Structure of atmospheric clouds. The author points out that for the produc-

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tion of cumulus the existence of a peplum is necessary, a condition of the surface which tends to preserve a definite form. This peplum is absent in the case of stratus. Throughout the paper the author uses the obsolete term of vapeur vésiculaire.

Meteorologische Zeitschrift. Redigirt von Dr. J. Hann und Dr. G. Hellmann, December 1893-May 1894. 4to.

The principal contents are:—Vergleiche von Quecksilber-Barometern mit Siede-Thermometern: von H. Hartl (10 pp.). This is an abstract of a paper published in the *Mittheilungen des K.K. Militär Geographischen Institutes* (see p. 80.).—Ueber die Ermittelung der Temperatur-und Feuchtigkeits-unterschiede zwischen Wald und Feld: von Dr. J. Schubert (7 pp.). This is an account of some interesting experiments carried on by the use of Assmann's apparatus for producing artificial air circulation round the bulbs of thermometers. The desirability of artificial uniform air circulation applied to wet-bulb themometers has long been recognised. Dr. Schubert claims to have shown by his experiments that the alleged difference in temperature and humidity between forest and open ground is solely due to the fact that the air inside the forest is calmer than outside, and that when simultaneous observations are carried on at any pair of twin stations, such as exist in all foreign meteorological systems, by means of Assmann's apparatus, the results are almost identical.—Klimatologische Zeit- und Streitfragen: von Dr. A. Woeikof. No. V. (9 pp.). In this paper the author discusses the regions where continental and oceanic climates are most strongly marked. He endeavours to show that the coldest winters on earth are probably over the Antarctic Continent, and the central portion of Greenland. The warmest summer is probably to be found in the Sahara or the Death Valley of California, and the greatest annual range in Eastern Siberia. One great sign of oceanic climate is the excess of warmth in autumn over spring. In Eastern Siberia, despite its oceanic climate, this relation exists, owing to the fact that snow melting retards the advent of summer in May. The region where spring is decidedly warmer than autumn is in Hindostan. Dr. Woeikof proceeds similarly to discuss relative humidity and precipitation, and concludes with a short notice of the typical oceanic climate of Jan Mayen and Northern Norway.—Ueber die Namen der Winde: von Dr. F. Umlauft (7 pp.). Hesiod only recognised four winds, but by the time of Herodotus the number of points had grown to eight. The names now generally employed are of Germanic origin, and Dr. Umlauft, by deriving their etymology from various languages, seeks to show that East implies clearness, West implies calm, as at sunset, North implies dampness, and so indicates a wind coming from the sea. South is said to be connected with the sun, as in Iceland the South wind is now called 'sunnanvindur.' The man to whom we owe the combination of the cardinal names to indicate intermediate points was Eginhart, in the time of Charlemagne. His windrose had only twelve points, for he left out South-south-east, West-south-west, North-north-west and East-north-east. The idea of combination was so practical that it was generally adopted, and completed so as to have sixteen points. Italy has never adopted this nomenclature; there East is Levante, sunrising; West, Ponente, sunsetting. The Sclav wind names are all taken from the course of the sun: the North is midnight; South, midday; East and West, rising and setting respectively.—Die Ergebnisse der schwedischen internationalen Polar-Expedition 1882-83 auf Spitzbergen, Kap Thordsen: von Dr. J. Hann (13 pp.). The author thinks that it has taken a long time to produce this work, but that its value and thoroughness have both been materially improved by the careful consideration which the discussion has received. Dr. Hann gives a summary of the contents of the volume. Among interesting facts it may be mentioned that hail was never once observed. The winter in Spitzbergen was the mildest experienced by any of the expeditions except that of the Austrians in Jan Mayen. The extremest cold in winter was reported by the Russians at the mouth of the Lena, the coldest summer by the Dutchmen in the Kara Sea. As regards the wind, the Swedes report that in winter the velocity was a maximum at night and a minimum in the forenoon. In summer this is reversed. The paper concludes with a list of the volumes in the *Zeitschrift* in which notices of all the Polar Expeditions are to be found, with their respective authors' names.—Neue Normaltemperaturen; von Dr. W Precht (10 pp.). This paper deals with the construction of

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isabnormal curves of temperature similar to those of Batchelder in the *American Meteorological Journal*, Vol. X. Dr. Precht refers to Spitaler's paper on temperature anomalies in *Petermann's Mittheilungen* for 1887, which, however, has only one chart for the year. Dr. Precht's own charts are not given in the *Zeitschrift*. The temperature charts on which they are based are Hann's in Berghaus' *Physical Atlas*. At the end of the paper the author takes up Angot's "Recherches origines sur la distribution de la chaleur à la surface du globe" from the *Annales du Bureau Central Météorologique de France* for 1893, which enable him to calculate normal temperatures by a different process, and the results agree very satisfactorily with those previously obtained by him.—N. Ekholm's Untersuchungen über das Verhalten des Psychrometers unter dem Gefrierpunkt: von J. Hann (9 pp.). This is a paper criticising the results given in the last volume of meteorological data of the Swedish expedition to Spitzbergen in 1882-3. Dr. Ekholm instituted a most careful investigation into the anomalous behaviour of the wet bulb, and finds that when the results are calculated by the usual formulæ for low temperatures the indications are considerably too high. He says that if the hygrometer is in good order, very good results for both vapour tension and relative humidity can be obtained down to very low temperatures if a constant correction of —0°·45 C, or 0°·81 F, is applied. The explanation given of this is that vapour of low tension is disseminated through the atmosphere with extreme slowness, consequently the tension of the vapour a few inches above a snow or ice surface is much higher than that in immediate contact with the snow, etc. The idea is that the thermometer bulb is brought into this surcharged stratum, vapour from that stratum condenses on the bulb and the latent heat raises the temperature of the bulb.—Die Vertheilung des Luftdruckes über Europa während der Trockenzeiten des Frühlings und Sommers 1893: von Dr. E. Less (16 pp. and plate). This is a discussion of the causes of the abnormal summer of 1893, a subject which has been frequently attacked. Dr. Less thinks that he has found the cause of the extraordinary persistence of the anticyclones in the fact that very unusual cold with an intense anticyclone prevailed over northern Russia throughout the spring and early summer.—Ueber die Einwirkung der ablenkenden Kraft der Erdrotation auf die Luftbewegung: von Dr. N. Ekholm (27 pp). This is a mathematical investigation into the action of the rotation of the earth on wind motion.—Die Resultate der meteorologischen Beobachtungen auf dem Pic du Midi: von Dr. F. Klongel (20 pp). This is an elaborate discussion of the work done on the Pic du Midi.

Meteorology, The Elements of Weather and Climate. By H. N. Dickson, F.R.S.E. 8vo. 1893. 192 pp.

This work forms one of the University Extension Series, and contains, in fact, the substance of a course of Lectures on Meteorology, delivered by Mr. Dickson as a University Extension Lecturer. The author deals with the subject in a clear and simple manner. The work is divided into 8 chapters, viz. fundamental facts; fundamental principles; cyclones; anticyclones; other forms of pressure areas; weather forecasting; meteorological instruments and observations; the elements of climate; and application of meteorology to agriculture.

Report of the Chief of the Weather Bureau, 1891-92. U.S. Department of Agriculture. 4to. 1893. 528 pp. and 4 plates.

This is the first volume of meteorological data published by the Weather Bureau, and contains the results of observations made during 1891 and 1892. Prof. C. F. Marvin contributes a description with illustrations of the instruments in use at the principal stations of the Weather Bureau; and Prof. Cleveland Abbe has a paper on instrumental corrections, methods of reduction, and resulting accuracy.

Symons's Monthly Meteorological Magazine. Vol. XXIX. Nos. 337-341. February-June, 1894. 8vo.

The principal articles are:—The January Frost (7 pp.).—A wet February in Edinburgh (1 p.).—Sun spots and air temperature (4 pp.).—The climate of Odessa (2 pp.).—Iridescence on the English Lakes (3 pp.).—The May Frost of 1894 (8 pp.).

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OCTOBER 1894.

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November	21, 1894	March	20, 1895
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By permission of the Council of the Institution of Civil Engineers, the above Meetings (except that of June) will be held at 25 Great George Street, Westminster, S.W.

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QUARTERLY JOURNAL

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VOL. XX. OCTOBER 1894. No. 92.

ON THE RELATIVE FREQUENCY OF DIFFERENT VELOCITIES OF WIND.

BY WILLIAM ELLIS, F.R.S.

(Plate IV.)

[Received April 10th.—Read May 16th, 1894.]

HAVING had occasion a few months ago to prepare some statistics in regard to wind velocity, I have since carried the inquiry somewhat further with the view of rendering the results more complete, and, with the permission of the Astronomer Royal, now beg to submit them to the notice of the Royal Meteorological Society.

The object of the paper has been to ascertain the number of hours during which the wind blew with each of the different hourly velocities experienced during the period under discussion. Such information may have a value, in view of the use of wind engines for pumping and other purposes, as affording some indication of the amount of work that may be expected from an

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engine constructed to act with a certain velocity of wind, as measured by a Robinson anemometer as usually constructed. The question being one on which I have more than once been asked to supply information, the results may be presumed to possess some general interest.

The discussion was confined to the five years 1888 to 1892, the record of the Robinson anemometer of the Royal Observatory, Greenwich (giving horizontal velocity), being employed. In tabulating from the records, the hourly velocity is entered to the nearest mile. On each day through the period mentioned the number of hours for each of the several velocities recorded was counted, placing in the first column the number of hours (if any) for which the tabulated value was either 0 or 1 mile; in the following column the number of hours of tabulated values of either 2 or 3 miles; and so on. The combination of the five months of January gave 155 days, or 8720 hours. February gave in all 142 days, or 8408 hours; March 8720 hours, and so on. In April and May there was a deficiency caused by the loss of record for nine days at the end of April, and eight days at the beginning of May, of the year 1889. In all other months the full number of days is available. The results (monthly sums of hours at different velocities) are given in Table I., the mean daily velocity for each month, on the mean of the five years, being also added. No regard has been paid to direction of wind.

The number of hours being necessarily different in different months, the monthly sums were not strictly comparable. To make them so they were proportionately altered where necessary, so as to correspond to monthly periods of 30 days, giving for each month of the year, in all 150 days, or 3600 hours. These corrected results will be found in Table II., the quarterly and yearly sums being also exhibited graphically in the diagram (Plate IV.).

In each quarter of the year (see Table II.) the wind blew for the greatest number of hours with the hourly velocities of 10 or 11 miles, and this was the case also in each separate month, excepting those of September and December. In autumn and winter nearly as many hours were registered at velocities considerably lower, but in spring and summer the numbers of hours at the corresponding lower velocities were distinctly less than at the velocities of 10 and 11 miles. With velocities greater than 11 miles, the number of hours very rapidly falls off, in all months of the year.

Comparing spring and winter taken together with summer and autumn taken together it is seen, neglecting velocities below 4 miles, that from velocities 4-5 miles to velocities 12-13 miles the wind blew for a greater number of hours in summer and autumn than in spring and winter, but that for velocities above 13 miles this is reversed, the number of hours in spring and winter being the greater, the difference increasing rapidly with increase of velocity. On consideration it will be understood that this is a result that might be expected. Summer and autumn are not seasons of heavy gales, so that the number of hours registered at moderate velocities will necessarily be greater than in spring and winter. On the other hand, the gales of spring and winter cause a greater number of hours of higher velocities to be then registered than in summer and autumn,

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TABLE I.—Numbers of Hours during which the wind blew with different hourly velocities in the years 1888 to 1892, as registered by the Robinson Anemometer (the Browning Instrument) at the Royal Observatory, Greenwich.

(As actually recorded.)

| Month. | Mean Daily Velocity. | Total Number of Hours. | Hourly Velocity of Wind in Miles. | | |

TABLE II.—Number of Hours during which the wind blew with different hourly velocities in the years 1888 to 1892, as registered by the Robinson Anemometer (the Browning Instrument) at the Royal Observatory, Greenwich.

(Reduced to months of 30 days, giving in the five years 3600 hours in each month.)

Month.	Hourly Velocity of Wind in Miles.																											
	0–1.	2–3.	4–5.	6–7.	8–9.	10–11.	12–13.	14–15.	16–17.	18–19.	20–21.	22–23.	24–25.	26–27.	28–29.	30–31.	32–33.	34–35.	36–37.	38–39.	40–41.	42–43.	44–45.	46–47.	48–49.	50–51.	52–53.	54–55.
	Number of Hours.																											
January....	145	226	316	374	393	421	325	347	257	186	132	127	77	62	65	44	25	21	19	15	9	7	4	2	1	..	..	..
February ..	182	208	285	340	353	478	307	387	288	204	167	124	89	59	35	30	19	27	7	6	5	..	..	..	..	..	..	..
March	67	118	240	335	392	469	311	335	246	249	249	139	149	105	75	51	22	17	8	6	7	1	..	1	6	2	..	..
April	75	184	384	413	415	556	376	353	237	190	160	96	83	35	21	16	5	..	1	..	..	..	..	..	..	..	..	..
May	104	237	370	462	504	524	342	341	227	139	132	71	46	31	18	14	12	13	4	7	1	1	..	..	..	..	..	..
June	145	229	382	501	533	571	400	310	219	138	102	37	24	8	1	..	..	..	..	..	..	..	..	..	..	..	..	..
July	93	205	308	429	530	627	427	357	217	143	109	54	36	27	18	15	4	1	..	..	..	..	..	..	..	..	..	..
August	77	153	344	517	502	554	378	335	259	149	121	74	49	31	23	19	7	4	3	1	..	..	..	..	..	..	..	..
September	138	308	426	552	517	521	314	264	195	170	82	40	33	16	14	4	5	1	..	..	..	..	..	..	..	..	..	..
October	117	234	394	467	462	516	293	278	247	180	162	75	55	36	40	15	3	11	7	2	4	1	1	..	..	..	..	..
November	145	341	414	376	409	456	326	261	203	163	135	89	60	45	43	40	33	18	18	16	4	1	1	1	..	..	1	1
December ..	225	400	471	389	343	360	295	254	199	161	140	90	79	67	31	23	12	13	14	8	4	5	3	6	3	4	..	1
Spring	324	510	909	1088	1160	1503	994	1075	771	643	576	359	321	199	131	97	46	44	16	12	12	1	..	1	6	2	..	..
Summer ..	342	671	1060	1392	1567	1722	1169	1008	663	420	343	162	106	66	37	29	16	14	4	7	1	1	..	..	..	..	..	..
Autumn ..	332	695	1164	1536	1481	1591	985	877	701	499	365	189	137	83	77	38	15	16	10	3	4	1	1	..	..	..	..	..
Winter	515	967	1201	1139	1145	1237	946	862	659	510	407	306	216	174	139	107	70	52	51	39	17	13	8	9	4	4	1	2
Spring and Winter	839	1477	2110	2227	2305	2740	1940	1937	1430	1153	983	665	537	373	270	204	116	96	67	51	29	14	8	10	10	6	1	2
Summer and Autumn	674	1366	2224	2928	3048	3313	2154	1885	1364	919	708	351	243	149	114	67	31	30	14	10	5	2	1	..	..	..	..	..
The Year ..	1513	2843	4334	5155	5353	6053	4094	3822	2794	2072	1691	1016	780	522	384	271	147	126	81	61	34	16	9	10	10	6	1	2

February, March, April = Spring; May, June, July = Summer; August, September, October = Autumn; November, December, January = Winter.

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Comparing together the values in any one of the vertical columns of Table II., we get an idea of the relative frequency of a given velocity of wind in different months of the year, that is an indication of the months in which the greatest number of hours for any particular velocity may be expected to occur. There is a certain irregularity in the values in the months of March and December, due to the mean velocity in these months (first column of Table I.) being, in March especially high, and in December remarkably low, an irregularity that, if a longer series of years had been employed, might have disappeared. Making some allowance for this, the numbers of Table II. may be seen to indicate generally the manner of distribution of wind velocity in different parts of the year. But considerable variation may be expected to occur in the same month in different years, as is indeed the case with the results for the separate years 1888 to 1892, which, having regard to economy of space, it was not thought necessary to give in detail.

The wind velocities here discussed depend on results deduced by use of the factor 3 (relation of movement of cups to velocity of wind). The effect of substituting a variable factor more nearly in accord with experiment (as kindly made by Mr. Dines) would be (see the diagram) to make the ascent to the maximum more steep, and the descent after the maximum more rapid, without really displacing the position of maximum (for which particular velocity the factor 3 as nearly as possible agrees), or indeed affecting the general relations of things indicated by the results as presented.

The revolving cups of the anemometer are 56 feet above the adjacent ground, and 211 feet above mean sea-level.

Addendum, June 20th, 1894.

On the occasion on which my paper "On the Relative Frequency of different Velocities of Wind" was read before the Society, a wish was expressed that I should add a table giving the corresponding hourly velocity of the wind at different hours of the day. I stated that this had not been done because the individual volumes of *Greenwich Observations* contained such information for each particular year. But it has since appeared to me that there would be convenience in adding this related information, and what I have done is to collect the results for the five years 1888 to 1892, as appearing in the separate Greenwich volumes, and combine them to form a table of mean values for the whole period (p. 242), thus providing results which are comparable with those given in the paper.

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MEAN HOURLY VELOCITY OF THE WIND, IN MILES, ON THE AVERAGE OF THE YEARS 1888 TO 1892, AS REGISTERED BY THE ROBINSON ANEMOMETER (THE BROWNING INSTRUMENT) AT THE ROYAL OBSERVATORY, GREENWICH.

Month.	Hour Ending.																								Mean.
	1 h.	2 h.	3 h.	4 h.	5 h.	6 h.	7 h.	8 h.	9 h.	10 h.	11 h.	Noon.	13 h.	14 h.	15 h.	16 h.	17 h.	18 h.	19 h.	20 h.	21 h.	22 h.	23 h.	Midnight.	
	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.
January	11·7	11·6	11·7	11·6	11·8	12·0	11·9	11·9	11·6	12·0	12·6	12·9	14·3	14·6	14·0	13·4	12·9	12·8	13·0	12·9	12·4	12·5	12·2	11·9	12·5
February	11·3	11·2	11·1	11·2	11·1	11·0	10·9	10·9	11·5	12·2	13·0	13·7	14·3	14·5	14·2	13·9	13·2	12·7	12·6	12·4	12·1	11·9	11·8	11·5	12·3
March	12·9	12·6	12·4	12·6	12·1	12·4	12·5	12·6	13·9	15·0	15·7	15·8	16·6	16·4	16·3	16·0	15·6	14·9	13·6	13·2	13·2	12·9	12·7	12·3	13·9
April	9·5	9·2	9·0	8·9	8·7	9·2	9·6	10·1	11·4	12·2	13·0	13·1	13·6	14·5	14·9	14·9	14·3	13·8	12·7	11·0	10·7	10·4	10·0	9·6	11·4
May	9·0	8·8	8·4	8·3	8·3	8·5	9·0	10·0	10·5	11·4	12·5	12·7	13·4	13·8	13·7	13·6	13·3	12·7	11·8	10·4	9·8	9·7	9·4	8·8	10·7
June	8·2	8·1	7·7	7·6	7·7	7·6	8·3	9·1	9·8	10·5	10·8	11·2	11·6	12·4	12·4	12·7	12·3	12·0	11·4	10·4	9·2	8·7	8·7	8·4	9·9
July	9·3	9·0	8·7	8·8	8·7	9·1	9·5	10·1	10·8	11·7	11·8	12·3	12·4	13·2	13·3	13·0	12·9	12·1	11·6	10·8	10·1	9·8	9·6	9·2	10·7
August	9·5	9·1	8·8	8·8	8·7	8·7	9·0	10·0	11·1	11·9	12·7	12·9	13·5	13·9	14·0	13·9	13·6	12·6	11·7	11·1	10·7	10·1	10·1	9·5	11·1
September	8·2	7·7	7·7	7·9	8·0	7·9	7·9	8·5	9·3	10·6	11·4	11·9	12·1	12·6	12·4	12·0	11·4	10·3	9·9	9·5	9·1	8·9	8·7	8·1	9·7
October	10·0	10·1	10·0	10·2	10·0	10·0	9·8	10·0	10·1	11·2	12·2	12·8	13·6	13·5	13·2	12·7	11·6	11·0	10·8	10·6	10·8	10·5	10·6	10·3	11·1
November	10·9	10·9	10·9	10·7	10·3	10·5	10·5	10·5	10·4	11·1	11·5	11·8	12·7	13·2	12·8	12·1	11·8	11·3	11·7	11·8	11·5	11·6	11·2	10·9	11·3
December	10·3	10·3	10·1	10·1	10·4	10·2	10·2	10·3	10·3	10·7	11·2	11·3	12·2	12·3	11·6	11·0	11·0	11·0	11·0	11·2	11·1	10·8	10·7	10·7	10·8
The Year	10·1	9·9	9·7	9·7	9·6	9·8	9·9	10·3	10·9	11·7	12·4	12·7	13·4	13·7	13·6	13·3	12·8	12·3	11·8	11·3	10·9	10·7	10·5	10·1	11·3

According to the experiments made by Mr. Dines, see *Greenwich Magnetical and Meteorological Observations 1889*, page lxiii., the hourly velocity registered by the Browning Instrument, for which the factor 3 exactly applies, is 11·7 miles, almost precisely the mean value of the above table.

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DISCUSSION.

Admiral J. P. MACLEAR said that it would be interesting to compare the results from the Greenwich wind records with observations of wind force at sea. The average rate of a sailing vessel was 120 miles a day, or about 5 knots an hour, a rate of travel which would require a wind force closely approximating the most frequent hourly velocity at Greenwich.

Mr. C. HARDING inquired whether any correction for friction had been applied to the observations, because he thought that probably friction might be the cause of some of the irregularities shown in the figures for hourly velocities of 12 to 18 miles. But, as Mr. Ellis had said, five years' results, though valuable, could not be regarded as affording trustworthy data, particularly, too, as the period discussed appeared to have been a more than usually calm series of years. It would be an interesting addition to the paper if the mean hourly velocities were given.

Mr. W. ELLIS, in reply, said that no correction had been applied to the figures, the tabulations having been made direct from the anemometrical records. Nothing had been said in the paper about hourly velocities, because the mean hourly velocities for each month in the year were given annually in the Greenwich volumes.

AUDIBILITY OF "BIG BEN" AT WEST NORWOOD UNDER CERTAIN METEOROLOGICAL CONDITIONS.

By WILLIAM MARRIOTT, F.R.Met.Soc.

[Read May 16th, 1894.]

In the year 1882, when preparing, in conjunction with the Hon. Ralph Abercromby, a paper on "Popular Weather Prognostics," I found that there was a lack of observations on the travel of sound—or audibility—in relation to meteorological conditions. As I could occasionally hear in my garden at West Norwood "Big Ben" of Westminster striking the hours, I decided upon recording in my note book whether I could hear the bell at the usual hours of observation, viz. 9 a.m. and 9 p.m. My garden, which was about 180 feet above sea level, was on ground sloping to the north, and was perfectly open in that direction. The Clock Tower at Westminster could be seen from the upper part of the house, and was distant about five miles and a half in a north by west direction.

The Clock Tower is situated at the northern end of the Houses of Parliament, and closely abuts on Westminster Bridge. The tower, which is 40 feet square, is surmounted by a richly decorated belfry and spire rising to the height of about 320 feet. The clock has four dials, which are 22½ feet in diameter. The minute spaces are a foot square, and the figures 2 feet long. The dials and hands cost £5,384, or more than the clock and the bells together.

The large bell, "Big Ben," weighs about 14 tons, and is 9 feet 5½ inches in diameter and 9⅛ inches in thickness. On one side of its waist is cast a representation of the portcullis of Westminster, and on the other side the

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arms of England. Round the outer lip is cast in Gothic letters: "This bell was cast by George Mears, of Whitechapel, for the clock of the Houses of Parliament, under the direction of Edmund Beckett Denison, Q.C., in the 21st year of the reign of Queen Victoria, and in the year of our Lord MDCCCLVIII."

The tone of the bell is E. The hammer weighs 4 cwt., and is lifted 18 inches from the bell, or about 9 inches vertically. The gearing is so arranged that the hammer falls exactly when the clock reaches the 60th second of the last minute of the hour; while at the 1st, 2nd, and 3rd quarters of the hour the first bell of the chimes is struck at those times respectively, the 4th quarter being let off about 20 seconds before the hour so that it may have done chiming before the hour begins at the real time.

The observations extended from October 1882 to November 1887, and were made as frequently as I could be sure that I was within range of hearing the bell at the *precise* time of striking. As the bell could at times be heard more distinctly than at others, I adopted the following scale, viz.:—

0 = when "Big Ben" could not be heard at all
1 = " " " be heard faintly
2 = " " " " distinctly
3 = " " " " very distinctly

There were in all 976 observations, which were distributed as follows:—

	9 A.M.		9 P.M.	
	No. of Obs.	per cent.	No. of Obs.	per cent.
"Big Ben" not heard	251	76·3	481	66·4
" " heard faintly	64	19·6	160	24·7
" " " distinctly... ...	8	2·4	51	7·9
" " " very distinctly ...	4	1·2	7	1·0

It will thus be seen that "Big Ben" could be heard more frequently in the evening than in the morning. This may possibly be due to there being less *noise*—such as that caused by trains, vehicles, machinery, &c.—in the evening than in the morning. With the view of testing this point still further, I extracted all Sunday observations, the results of which show that the bell can be heard to much greater advantage on Sundays than on week days:

Sunday observations	9 A.M.		9 P.M.	
	No. of Obs.	per cent.	No. of Obs.	per cent.
"Big Ben" not heard	86	72·9	78	60·0
" " heard faintly	22	19·5	34	26·2
" " " distinctly	5	4·3	15	11·5
" " " very distinctly ...	4	3·3	3	2·3

The results of the observations are shown graphically in the accompanying diagrams, in which the thick lines represent the percentage of audibility on the number of observations given in figures at the bottom of each line.

Wind.—"Big Ben" was most frequently heard with winds from West to North, and less frequently with winds from South to East. (Fig. 1.)

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The percentage of audibility was greatest on Sunday evenings, "Big Ben" being heard with all winds, but most frequently, as before, from West to North. (Fig. 2.)

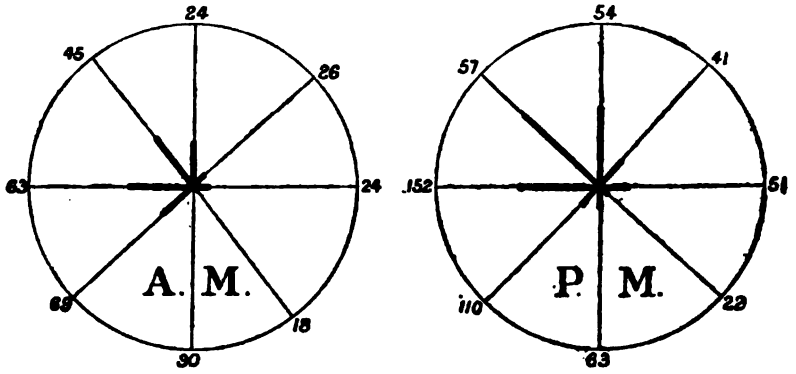

FIG. 1.—Audibility of "Big Ben" with different Winds. The thick lines show the percentage of audibility and the figures at the extremity of the radii the number of observations.

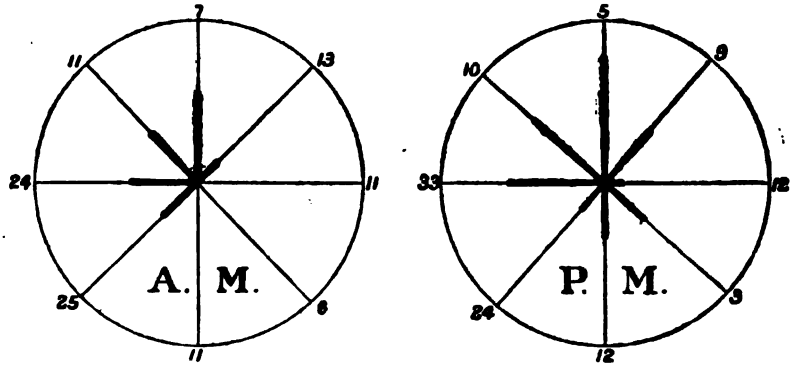

FIG. 2.—Audibility of "Big Ben" with different Winds. Sunday Observations only.

Barometer.—From the morning observations it appears that the percentage of audibility was greater with the low and the high readings of the barometer than with the intermediate readings. A somewhat similar grouping appears in the evening observations, although the differences in the percentages are not so marked as in the morning observations. (Fig. 3.)

From an examination of the *Daily Weather Charts* for a number of days on which "Big Ben" was heard, it appears that the conditions most favourable for audibility are when a cyclonic disturbance is to the eastward of London or when an anticyclonic area is in the neighbourhood. Under some such circumstances there is a tendency for the wind to blow as a downward current, and so probably to carry the sound for a greater distance along the surface of the earth, than when other conditions prevail, as when the wind

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has an upward tendency and will carry the sound rather in an upward direction than along the surface of the ground.

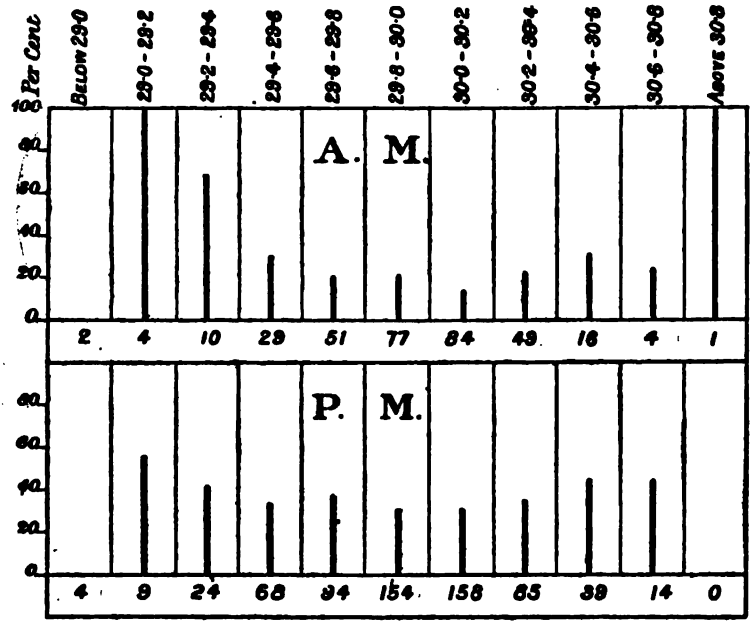

FIG. 3.—Audibility of "Big Ben" with different heights of the Barometer. The thick lines show the percentage of audibility, and the figures below the number of observations.

On two occasions the quarter chimes were also heard. These were: (1) on Sunday, October 17th, 1886, at 9 p.m., when we were in the rear of a slow moving depression; and (2) on Wednesday, March 30th, 1887, at 9.30 p.m., when we were on the eastern side of an anticyclone.

Temperature.—In the morning the percentage of audibility appears to be greater with low temperatures than with high temperatures. As possibly the low temperatures occurred with radiation weather, there might be a downward current which would be favourable for audibility; while with the higher temperatures there would probably be an ascending current, which would be unfavourable for audibility.

The percentages of audibility are much more uniform in the evening, when probably the air has mostly a downward tendency. (Fig. 4.)

Cloud.—The percentage of audibility in the morning appears to be greater with clear skies than with cloudy ones, while in the evening the opposite occurs. (Fig. 5.)

A curious point brought out by these observations is that the sky was most frequently overcast at 9 a.m., and that at 9 p.m. it was either clear or overcast, the intermediate amounts of cloud being very small.

Difference between Dry and Wet Thermometers.—The percentage of

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audibility appears in the morning to be greatest when the difference between the dry and wet bulb thermometers was from 1° to 8°; while in the evening the percentages are much more uniform. (Fig. 6.)

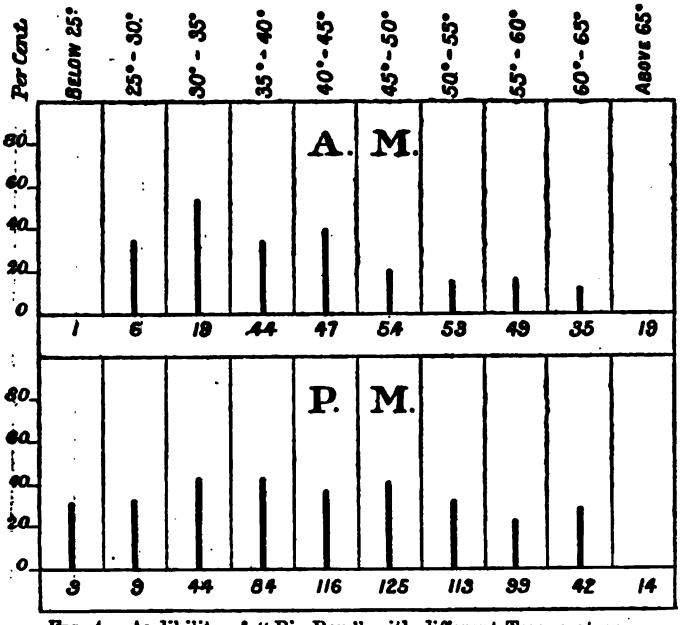

FIG. 4.—Audibility of "Big Ben" with different Temperatures.

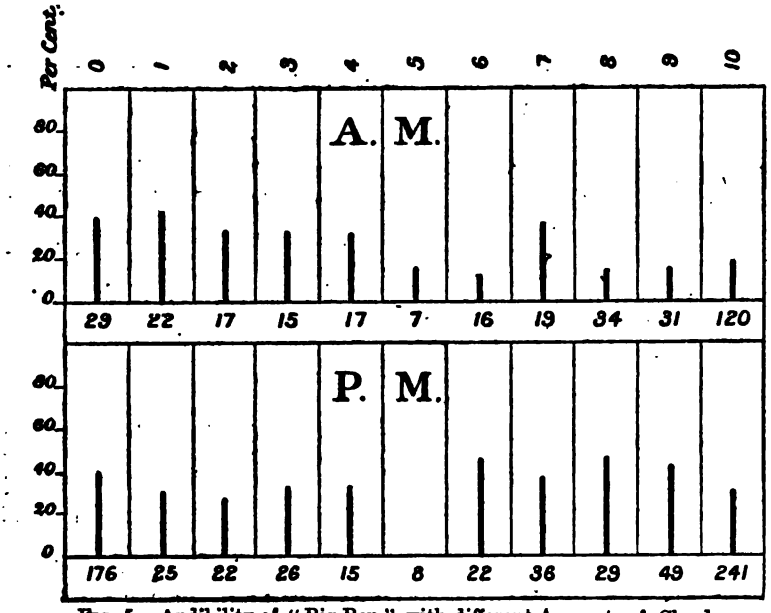

FIG. 5.—Audibility of "Big Ben" with different Amounts of Cloud.

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Dr. Tyndall, on January 16th, 1874, at the Royal Institution, gave a lecture "On the Acoustic Transparency and Opacity of the Atmosphere," which embraced the scientific results of an inquiry on fog signals, undertaken at the instance of the Elder Brethren of the Trinity House. In con-

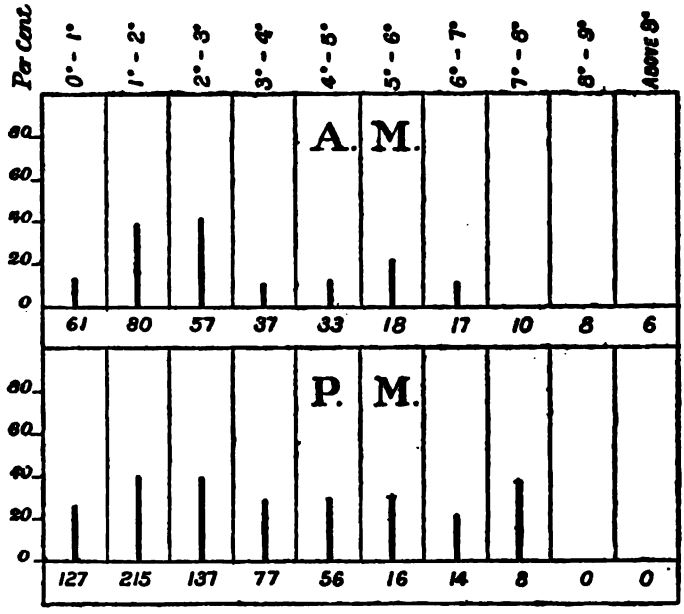

FIG. 6.—Audibility of "Big Ben" with differences between the Dry and Wet Thermometers.

cluding the lecture he said: "The real enemy to the transmission of sound through the atmosphere has, I think, been clearly revealed by the foregoing inquiry. That enemy has been proved to be not rain, nor hail, nor haze nor fog, nor snow—not water, in fact, in either a liquid or a solid form—but water in a vaporous form, mingled with air so as to render it acoustically turbid and flocculent. This acoustic turbidity often occurs on days of surprising optical transparency. Any system of measures, therefore, founded on the assumption that the optic and acoustic transparency of the atmosphere go hand in hand must prove delusive."[1]

DISCUSSION.

THE PRESIDENT (Mr. R. Inwards) said that it was interesting to find that there was a fair degree of agreement between the amount of cloud and the audibility of "Big Ben." It would be interesting if the height and form of cloud could be considered in this connection, as it was conceivable that a sheet of stratus cloud would be more effectual in reflecting the sound earthwards than would clouds of irregular form.

[1] *Proceedings of the Royal Institution.* Vol. VII. p. 178.

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Mr. F. GASTER said that his residence in Acre Lane, Brixton, was about 8 miles due south of "Big Ben," but he was sure that he heard the clock bell more frequently with Westerly than with Northerly winds. This curious state of things was to be partly accounted for by the fact that Westerly winds were the winds of greatest frequency, but there was one condition of pressure distribution which also assisted in producing this effect. When a depression had passed over London, and pressure became highest in the south, the wind frequently was West-south-west at the earth's surface, while at a comparatively short distance above the earth it blew from a North-westerly direction, and it was this upper current which conveyed the sound.

Capt. D. WILSON-BARKER alluded to some experiments which had been carried out in American waters, in which a distinction had been drawn between reflected sounds and sounds which came direct. The manner in which sounds were heard at sea was most curious, and a small sail on a vessel had been known to reflect the sound of a whistle in an altogether astonishing manner.

Mr. R. H. SCOTT drew attention to the reports published by Professor Mohn in the *Annalen der Hydrographie* for 1892 and 1893 of his inquiries into fog signals. These were conducted at the Island of Färder, in the Christiania Fjord, as complaints of the frequent inaudibility of the Färder siren had reached Christiania. The island is isolated, so that the sound could be tested in all directions. An abstract of results given in the first report will be found in the *Quarterly Journal*, Vol. XIX. p. 61. The chief fact is that sounds are heard best to leeward, and better across the wind than to windward. They travel better in warm than in cold weather, but under all circumstances there are great variations, as yet unexplained, in the audibility of sounds. They are heard better at the mast head than on deck, evidently because the sound waves are reflected from horizontal strata of air. The second report deals with an attempt to account for the variability of the distance at which the sound can be heard.

Mr. G. J. SYMONS said that when he first went to reside in Camden Town (which was north of Westminster) in 1857, he was accustomed to hear "Big Ben" twice or thrice a week; but now, owing probably to the increase in buildings, &c., the bell was rarely heard more than once in three weeks or so. The audibility of "Big Ben" was regarded at his house as an infallible sign of wet weather. It was rarely heard except with wind at South-south-east to South-south-west, and rarely except at night, when the traffic in town was less.

Mr. R. H. CURTIS said it appeared to him that the paper merely showed the relative frequency of Northerly winds at Mr. Marriott's residence, and all the phenomena mentioned were such as one would expect to find with such winds. The wind diagrams showed that the sound was only heard when the wind was Northerly or North-westerly, and with such winds there would of course be either a low pressure area to the eastward or an anticyclone to the westward, as Mr. Marriott said was the case; in the former cases, the depression having passed away to the eastward, the sky would have cleared and the amount of cloud would be small, while in the latter the sky would generally be overcast, and thus there would be the two extremes of cloudiness mentioned; and in both cases one would expect a low, or relatively low, temperature.

Admiral J. P. MACLEAR remarked that the difference in the audibility of the voices of ships' officers in stormy weather at sea was very remarkable, and strong-voiced men who shouted their orders could only be heard at a short distance, while weaker voices, but of a reedy quality, were audible for the whole length of the ship. He (Admiral Maclear), when a lieutenant, had to make his voice heard throughout three decks, and he found that the best way to accomplish this was to intone the orders.

Mr. W. ELLIS said that he also had not unfrequently heard "Big Ben" at Greenwich, which was about the same distance from Westminster as West Norwood. That it was really "Big Ben" that was heard was known by noting the interval between the successive strokes in striking the hour.

Mr. C. HARDING said that he resided at Brixton, on the south side of "Big Ben," and always regarded the audibility of the bell as indicative of fine weather. Concerning the question of inversion of temperature, Mr. Glaisher in his balloon ascents had found at evening time an increase of temperature with elevation above the earth's surface, extending to a height of 2,000 feet.

Dr. A. BUCHAN said that the audibility of sound depended upon the homo-

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geneity of the atmosphere, and vertical air currents would disturb this condition. In the summer there would be ascending currents with a warm temperature in the morning, and descending currents with a cooler atmosphere at night, consequently the hours of 9 a.m. and 9 p.m. were rather unfavourable to the distinct transmission of sound. A more suitable hour of observation would be about 4 p.m. In the rear of cyclones, when North-westerly winds prevailed, the atmosphere was most homogeneous, as the temperature was even and the wind current deep and strong. The difference between the audibility in the morning and evening was doubtless due to the difference in the noise in London at the hours of observation as well as of atmospheric conditions.

Mr. W. MARRIOTT, in reply, said that his observations of the audibility of "Big Ben" had been brought to an end, owing to his removal to a house situated on the south-east slope of a hill where "Big Ben" was very rarely heard, although the distance between this and the former place of observation was only a quarter of a mile. The observations discussed in the paper were fairly distributed over the year. The effect of the inversion of temperature on the transmission of sound was an interesting question, and it would be a good thing if a set of meteorological observations were made at the top of the Westminster Clock Tower.

EARTH TEMPERATURES AT CRONKBOURNE, ISLE OF MAN, 1880-89.

By A. W. MOORE, M.A.

[Received April 27th.—Read May 16th, 1894.]

THE following are the results of 10 years' observations, at 9 a.m.,[1] of the temperatures recorded by thermometers placed respectively at 1, 2, 3, and 4 feet below the level of the ground (Table I.), as compared with the shade temperature at 4 feet above it, taken at 9 a.m. and 9 p.m. and 9 a.m. only, and with the daily minimum on the grass. Generally speaking, the results are very much what might have been expected *a priori*, but still the variations of temperature are curious and interesting. The highest annual mean, 48°·5, has been recorded at 4 feet below the ground; 3 feet being next, with 48°·4; 2 feet, with 48°·3; 1 foot, with 47°·8; while the mean shade temperature at 9 a.m. and 9 p.m. for the same period was 47°·9, and at 9 a.m. only, 49°·0. It will be noticed that all these underground temperatures, except that at 1 foot, are above the mean annual temperature, taken at 9 a.m. and 9 p.m., at 4 feet above the ground, but this may be partly accounted for by the underground thermometers being momentarily exposed to the air[2] at 9 a.m., when the temperature is higher than the mean between 9 a.m. and 9 p.m.; also that the variation of temperature between the different levels is not similar, that between 1 and 2 feet being 0°·5, between 2 and 3 feet, 0°·1, and between 3 and 4 feet, 0°·1.

[1] The thermometers are fastened to a wooden lath enclosed in a round iron tube.

[2] The thermometers were pulled up, read, and pulled down in about 15 seconds, but it should be noted that the 1 foot thermometer would be exposed a slightly longer time to the influence of the outside temperature than the one at 2 feet, and so on.

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The next point we may note is that, while the thermometer at 1 foot below the ground attains its maximum of 57°·2 in July, and its minimum of 40°·5 in January, corresponding with the shade temperature[1] of 56°·9, and of 40°·8 in the same months; the thermometer at 2 feet attains its maximum of 56°·6 in August, and its minimum of 41°·6 in February; and the thermometers at 3 and 4 feet attain their maxima of 55°·9 and 55°·6, respectively, in August, and their minima of 42°·1 and 42°·6 in March.

It will be observed also that, at 4 feet below the ground, October is warmer than May; at 2, 3, and 4 feet below, September is warmer than June; and, at 4 feet, not only is December warmer than April, but November is warmer than May, all these being the exact reverse of what obtains above ground.

The temperatures below the ground tend to follow the same laws as temperatures on the surface of the sea in attaining their maximum later in the year than on the ground or above it, and their minimum later in the year than above the ground.

Another point of comparison is the variation of temperature between the warmest month and the coldest, which, referring again to Table I., is, at 1 foot, 16°·7, at 2 feet, 15°·0, at 3 feet, 13°·8, at 4 feet, 13°·0, that at 4 feet above the ground being 16°·6. It will also be observed that these variations of the underground thermometers, like those previously referred to, are not similar, that between 1 and 2 feet being 1°·7, that between 2 and 3 feet, 1°·2, and that between 3 and 4 feet, 0°·8.

TABLE I.—MEAN MONTHLY GROUND TEMPERATURES, AT 9 A.M., 1880-1889.

Month.	Below Ground.				On Ground.	Above Ground.	
	1 ft.	2 ft.	3 ft.	4 ft.	Grass Min.	9 a.m. and 9 p.m.	9 a.m.
	°	°	°	°	°	°	°
January	40·5	41·7	42·5	43·2	32·3	40·3	40·3
February ..	40·7	41·6	42·1	42·7	34·0	40·7	41·2
March	40·5	41·8	42·1	42 6	31·8	40·8	41·6
April	43·9	44 2	44·1	44·3	34·5	44·6	46·0
May	49·0	48·4	47·9	47·6	38·6	49·5	51·4
June	54·4	53·5	52·4	51·7	43·9	55·0	57·1
July	57·2	56·4	55·4	55 0	47·7	56 9	58 8
August	57·0	56·6	55·9	55·6	46 6	56·9	58·9
September ..	54·4	54·8	54·7	54·7	43·8	54·5	56·3
October ..	49·0	50·3	51·2	51·5	38·5	48·6	49·8
November ..	45·2	46·7	47·6	48·2	35·9	45·2	45·6
December	41·8	43·6	44·5	45·3	31·7	41·4	41·4
Year	47·8	48·3	48·4	48·5	38·3	47·9	49·0

It is curious, too, that the greater variation at 1 foot below the ground should be slightly more than at 4 feet above it, but this is partly caused, no

[1] These comparisons are made with the temperature at 9 a.m. and 9 p.m., not with that at 9 a.m. only.

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doubt, by the former temperatures being taken at 9 a.m. only when the temperature varies more than at 9 p.m. The thermometer at 1 foot below the ground registers, as might have been expected, the lowest temperatures of the four in the coldest months, viz. January, February, March, April, October, November, and December, and the highest temperatures in the warmest, viz. May, June, July, and August.

As regards the thermometers at 2 and 3 feet, that at 2 feet is warmer than 3 feet in April, May, June, July, August, and September, and colder in the other months.

It will be seen that in all cases there is practically no rise of temperature from the lowest point till April, and that it then increases less rapidly at 2 feet than at 1 foot, at 3 feet than at 2 feet, and at 4 feet than at 3 feet, till between June and July, when the process is reversed and the lowest thermometer increases most rapidly. Between August and September a general decrease begins, being most rapid at 1 foot, and least rapid at 4 feet, and so continues till between December and January, when the lowest thermometer again descends most rapidly.

It will be observed from Table II. that the temperature under the ground varies less from year to year than that above it. Thus, in the years before us the year 1881, taking an average of the temperatures at from 1 to 4 feet, was the coldest both below and above ground, and the year 1884 the warmest. The mean difference between the temperature below ground of 1884 and 1881 was 1°·7, and that above ground 2°·2.

TABLE II.—YEARLY GROUND TEMPERATURES AT 9 A.M., 1880–1889.

Years.	Below Ground.				Grass Min.	Above Ground 4 ft.
	1 ft.	2 ft.	3 ft.	4 ft.		
	°	°	°	°	°	°
1880	48·6	48·9	48·9	48·9	40·2	48·4
1881	47·0	47·6	47·5	47·8	37·9	46·8
1882	48·6	48·9	49·1	49·6	40·0	48·6
1883	47·5	48·00	48·0	48·4	39·1	47·6
1884	48·7	49·1	49·3	49·3	39·3	49·0
1885	47·0	47·6	47·7	47·9	37·6	47·2
1886	47·2	47 8	47·8	47·9	38·4	47·2
1887	47·7	48·4	48·6	48·8	36·1	47·8
1888	47·2	47·8	47·8	48·0	37·0	47·5
1889	48·6	49·0	48·9	49·0	37·3	48·8

There appears to be comparatively very little connection between the temperature on the ground (grass) and below it, as the temperatures below the ground both, from year to year and from month to month, follow those at 4 feet above the ground much more closely than those on the ground.

DISCUSSION.

Dr. W. MARCET said that having recently had occasion to make an investigation concerning earth temperatures, the question had arisen in his mind as to whether a thermometer enclosed in an iron tube sunk in the soil was the best form of exposure for ascertaining the temperature of the earth. In order to

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satisfy himself on this point he had a special thermometer constructed and buried in the soil, its bulb being two feet below the surface, and compared its indications with those from a thermometer placed in an iron tube (the usual form of earth thermometer) at a similar depth in the ground. The results of this comparison showed that the indications of the two instruments accorded very closely, the thermometer in contact with the soil reading about 0°·5 lower in cold weather, and the difference becoming less in warmer weather. The comparative observations were carried on from February to May of the present year, and were brought to an end through the breakage of the thermometer buried in the soil.

Mr. J. G. Symons said that the statement made by Dr. Marcet was very satisfactory, as he (Mr. Symons) had always advocated the exposure of earth thermometers in iron tubes. A comparison between Mr. Moore's observations and the results of a series of 21 years' similar observations at Munich, published by Dr. K. Singer, showed that both agreed very well together, and followed the known laws concerning the distribution of temperature below the earth's surface.

Fogs reported with Strong Winds during the 15 years 1876-90 in the British Isles.

By ROBERT H. SCOTT, M.A., F.R.S.

[Received May 31st.—Read June 20th, 1894.]

In the paper which I had the honour of submitting to the Society in June 1893, and which was printed in the *Quarterly Journal*, Vol. XIX. p. 229, attention was drawn to the instances of the occurrence of fog with forces of wind of 6, and upwards, on Beaufort's scale, and that portion of the paper received special notice in the discussion of the entire communication.

It has since struck me that the conditions under which these fogs were reported were worthy of further study, and that the Society might possibly tolerate a further notice on the subject. I venture therefore to submit the results of some investigations into this somewhat obscure phenomenon.

Firstly, the conditions of pressure under which these fogs have been reported have been examined, in order to learn whether these were cyclonic or anticyclonic.

Secondly, the actual weather reported on each occasion has been noted, whether simply "f," or qualified by any other letter or letters, such as "o, u, d, f," (overcast, ugly, drizzle, and fog,) which was the report for Dover on November 28th, 1878. It should be remembered that these letters are intended to convey an account of the weather which has prevailed during the preceding twenty-four hours, and that they do not imply that all the different phenomena described appeared at once.

Thirdly, there have been extracted not only the temperature for the hour at which the fog was reported to have been present, but also the maximum

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temperature for the 24 hours to which the observation belonged. It is evident that if the fog occurred at 6 p.m. this maximum temperature, recorded next morning, represents the true maximum for the day on which the fog was reported; but that if the fog was reported at 8 a.m. the maximum temperature then observed would refer to the 24 hours preceding that particular epoch.

Fourthly, the rain has been extracted for the preceding and the succeeding days, except in the case of the 6 p.m. fogs, where the only entry is that for the day of which 6 p.m. is nearly the middle point, that is the rain reported at 8 a.m. next morning.

To each case a few notes are appended, as to the general conditions of pressure and weather prevailing at the time.

In the first place it should be remarked that these fogs do not occur with typical anticyclonic conditions. This fact is obvious, inasmuch as a wind force of 6, Beaufort scale, implies steep gradients, and these are incompatible with the existence of an anticyclone. The fogs can only occur on the outskirts of the anticyclone, and as usually cyclones press rather closely upon anticyclones, it is often somewhat difficult to decide to which system the reported fog properly belongs, whether to the cyclone or the anticyclone. An attempt has, however, been made to form a judgment on each case, and, as a result, the accompanying table is submitted, showing the number of the fogs attributed to each category, referred to winds from each quadrant of the compass.

As to the total number of strong wind fogs, the number given in the original paper was 128, but subsequent inquiry had added 7 to the list, and the total now given for the 15 years is 135.

The following is the classification :—

Wind's from	Cyclonic	Anticyclonic or doubtful	Total
N to ENE ...	7 ...	0 ...	7
E to SSE ...	13 ...	5 ...	18
S to WSW ...	81 ...	14 ...	95
W to NNW ...	7 ...	8 ...	15
Total	108	27	135

In 12 instances fog was reported at more than one station at the same hour.

As regards precipitation, it need scarcely be said that in general none occurs with ordinary fogs. In the case of the strong wind fogs, now under consideration, this is far from being a correct statement, although dryness is the predominant condition of those classed under anticyclones. Of the 27 cases of the latter class of fog 21 were dry, or at least unaccompanied by as much as 0·1 in. of rain. Of the 108 cases classed as cyclonic fogs only 30 were dry to the same extent, and 78 were either accompanied with, or followed

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immediately by, rain, sometimes heavy, and in 18 cases exceeding half-an-inch. It is therefore evident that the majority of these fogs are essentially wet fogs.

We now come to the question of the temperature accompanying these fogs, and here a very remarkable relation comes out. The temperature at the epoch of these fogs is not uncommonly the maximum temperature of the day.

All the cases have been picked out in which the temperature at the time the fog was reported either agreed with the maximum for the day or fell only 1° below it.

Of the 27 anticyclonic fogs 11 fulfilled this condition, and of the 108 cyclonic fogs 61 fulfilled it.

Accordingly, out of the whole number of 135 fogs no less than 72, or 54 per cent., occurred with temperatures either agreeing with, or very close to, the maximum for the day. If we take in the temperatures differing 2° from the maximum we increase the total of warm fogs to 92 and the percentage to 69.

Such a condition as this is rare in the case of our ordinary calm weather fogs. These occur usually with a sky clear above the fog, as is evident to everyone, and when radiation is consequently active; for frequently when a fog is dense enough at the surface of the ground, the sun, or moon, as the case may be, is visible through the fog, whereas any ordinary cloud suffices to obscure these luminaries entirely. However, this question of the relation of fogs in general to temperature seems to promise further results of interest, and it may be possible to find material for further communications if the Society should wish to receive such.

It appears interesting to examine into the relation of these strong wind fogs to storms. They sometimes occur with actual gales, and there were 11 such instances among the fogs classified as cyclonic. No less than 25 cases are put down as "preceding severe gales." That fogs sometimes occur just before gales is well known, and several such instances will occur to most persons' memories. They are frequently only the last dregs of a regular anticyclone fog, to be dispersed by the incursion of the gale.

All the considerations put forth in this paper appear to show that we have had to deal with a class of phenomena quite distinct from those accompanying the typical fogs of a London winter.

The fact of a high temperature heralding a winter gale is well known, and as these strong wind fogs occur much more frequently with winds from the quadrant from South to West-south-west than with other winds, the Southerly winds being the winds in the front part of the cyclonic system, it may be expected that the fogs will also be accompanied by high temperature.

The overwhelming majority of these cyclonic fogs with South-westerly winds—81 out of 108—and their much greater prevalence on the south-west coast (Scilly, Pembroke, Prawle Point) than elsewhere, point distinctly to their marine origin. They come in to us from the Atlantic Ocean.

They are apparently very thick mist, or very dense rain, and, in my opinion, as expressed in my previous paper, they should not receive the name of "fog," but that of "mist,"

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Cyclonic Fogs.

Winds from N to ENE.

Date.	Station.	Weather.	Wind.	Temperature. Max.	Temperature. Temp.	Rain. Preceding.	Rain. Succeeding.	Notes.
				°	°	In.	In.	
1877. May 19	Stornoway	d f	NNE	47	51	·12	·02	On Northern side of shallow depression
,, ,,	Sumburgh Head	f	ENE	46	*	·11	·01	
1878. Nov. 28	Dover	o u d f	NNE	46	48	·11	·64	In middle of secondary over Straits of Dover. NE gale in Channel
1879. April 10	Scilly	o f	NNE	46	53	·01	·03	Stiff NE breeze in Channel
,, May 30	Sumburgh Head	f	NE	49	59	·00	·00	Cyclonic, complex situation
1881. Jan. 19	Pembroke	b o f	NE	28	32	·00	·05	(Snow.) Day after "blizzard"
1886. April 20	Yarmouth	f g	ENE	42	46	·00	·01	Strong E winds

Winds from E to SSE.

1876. Nov. 15	Wick	f	SE	50	*	·81	·00	1·77 in. Aberdeen; 1·50 in. Ardrossan; exceedingly heavy rain about; depression off North-west Coasts
1877. Jan. (	Roche's Point ..	r f	SE	48	49	·22	·75	Before heavy South gale
1879. Feb. 10	Scilly	o d f	SSE	50	51	·24	·11	Barometer very low, see SSW, Pembroke
,, Mar. 25	Dover.....	o f s	E	33	36	·02	·04	Before E gale, force 10 at Scilly
,, July 31	Pembroke	o f	SSE	58	62	·19	·08	Small shallow depression off Cork. See Scilly, SSW
,, Sept. 7	Wick	f	SE	53	55	·03	·01	Before slight gale; fog very general on NE coasts
1880. Mar. 16	Scilly	r f	ESE	48	49	·01	·16	SE gale in Ireland; before E gale Scilly
,, ,, 17	Scilly	r f	E	49	*	·16	·37	
1881. Feb. 14	Pembroke	r f	SE	43	45	·36	·35	In slight gale. See Scilly, S
1882. April 22	Roche's Point ..	r f	SE	51	55	·24	·25	Depression advancing to Ireland from West
1883. Mar. 21 6 p.m.	Hurst Castle....	f	ESE	39	45	..	·06	Before East gale
,, June 26 6 p.m.	Wick	f	ESE	58	*	..	·00	Before gale, SSE 9; Stornoway
1887. Jan. 11	Pembroke	f	SSE	48	*	·40	·17	In gale in front of a "V" shaped depression

Winds from S to WSW.

1876. Jan. 29	Valencia	f	SSW	49	51	·03	·93	Depression outside North-west of Ireland
,, Jan. 30	Pembroke	f	S	48	*	·09	·09	
,, Feb. 17	Pembroke	f	SW	49	*	·40	·16	Heavy rain all about
,, Feb. 28 6 p.m.	Scilly	f	SW	52	55	..	·16	Rain very general
,, Mar. 3	Pembroke	o f	SW	49	*	·12	·02	Beginning of slight gale
,, Sept. 26	Scilly	o f d	WSW	58	65	·27	·01	Depression over Cork, moving eastwards

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CYCLONIC FOGS.

Winds from S to WSW—*Continued.*

Date.	Station.	Weather.	Wind.	Temperature.		Rain.		Notes.
				Min.	Max. Temp.	Preceding.	Succeeding.	
				°	°	In.	In.	
1876. Dec. 29	Roche's Point ..	r f	S	50	52	·18	1·26	Stiff SW gale coming on
1877. Jan. 16	Scilly	f	SSW	52	*	·07	·15	Next day 0·4 of rain exceeded at 6 Western Stations
„ Jan. 23	Roche's Point ..	r f	S	50	*	·12	·45	Preceded heavy rain for 2 days in S. of Ireland. 0·7 and 0·8 at Valencia. Slight S gale
„ May 17	Scilly	o d f	WSW	54	57	·74	·00	In centre of small depression moving East
„ June 2	Pembroke	r f	SW	52	56	·46	·03	In stiff breeze, not heavy gale
„ „	Scilly	d o f	SW	55	57	·04	·01	
„ Aug. 27 6 p.m.	Scilly	f	SW	62	64	..	·05	Preceded stiffish breeze
„ Aug. 27	Pembroke	o f r	SW	61	62	·49	·20	
„ Oct. 30	Roche's Point ..	r f	SSW	55	57	·11	·15	Preceded SW gales
„ Dec. 28	Roche's Point ..	r f	S	47	*	·25	·40	Preceded stiff breeze and very heavy general rain
1878. Jan. 20	Scilly	f	SW	51	52	·05	·02	
„ Feb. 15	Scilly	f d	SSW	52	*	·09	·05	Strong SW winds, occasionally force 8
„ „ 6 p.m.	Hurst Castle....	f d	SW	49	50	..	·07	
„ Feb. 16	Scilly	o f	S	50	53	·05	·04	
„ Feb. 28	Scilly	f d	SW	53	*	·16	·11	Before slight gale
„ Apr. 13	Scilly	f d	S	52	54	·86	·02	Depression lying off W of Ireland, 1·15 rain Valencia. 0·96 Roche's Point
„ Nov. 24 6 p.m.	Scilly	f	SSW	52	54	..	·13	In front of small depression
„ Dec. 30	Dover	o f r	WSW	49	*	·08	·23	Before SW gale
1879. Jan. 13	Scilly	f d	WSW	51	*	·12	·25	Probably cyclonic. Anticyclonic over France
„ Feb. 9	Pembroke	f	SSW	47	48	·58	·03	Very complex system, bar. 29·19. See Scilly, SSE
„ April 7	Wick	f	S	42	49	·01	·35	Very heavy rain Aberdeen and Thurso; before slight SE gale
„ June 19	Scilly	o f	S	53	57	·03	·22	Before and in South gale
„ July 7	Scilly	f d	WSW	57	60	·13	·02	Before WSW gale
„ July 19 6 p.m.	Scilly	f	SW	58	*	..	·32	In gale
„ July 20	Pembroke	f	WSW	56	57	·34	·06	In a gale
„ „	Prawle Point ..	f	SW	56	58	·48	·00	
„ July 31	Scilly	o f p	SSW	60	62	·21	·08	See Pembroke, SSE
„ Aug. 20	Scilly	f d	SSW	62	*	·42	·16	Very heavy rain about. 1·21 Hurst, 1·13 Oxford
„ Sept. 2	Ardrossan	f d	SSW	53	58	·28	·29	Fresh winds, slight gale Mullaghmore
„ Dec. 28	Pembroke	o f	SW	49	50	·19	·08	Before and in gale
1880. Feb. 20 6 p.m.	Scilly	f	SW	49	52	..	·04	Heavy gale in North, forces 9 and 10
„ Dec. 22	Pembroke	r f	WSW	52	*	·44	·20	Before gale
1881. Feb. 13 6 p.m.	Scilly	f d	S	50	52	..	·35	In slight gale, force 7 at seven stations. See Pembroke, ESE
„ Dec. 24	Ardrossan	o f	S	44	*	·00	·62	In gale, anticyclone just broken up

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Cyclonic Fogs.

Winds from S to WSW—*Continued.*

Date.	Station.	Weather.	Wind.	Temperature.		Rain.		Notes.
				Min.	Max. Temp.	Preceding.	Succeeding.	
				°	°	In.	In.	
1882. Jan. 5	Valencia	f g	WSW	53	*	·49	·10	Before gale
,, Jan. 6	Ardrossan	b f	WSW	44	50	·43	·21	In heavy gale
,, June 5 6 p.m.	Scilly	d f	SW	57	58	..	·58	
,, July 14 6 p.m.	Scilly	r f	S	59	63	..	·35	In slight gale
1883. May 12	Holyhead	f q	SSW	50	51	·17	·07	Slight gale; force 7 at several stations, 9 at Valencia
,, ,,	Prawle Point ..	f	SSW	50	51	·46	·00	
,, May 13	Holyhead	r f q	SSW	50	54	·07	·00	
,, Aug. 9	Liverpool	f	WSW	55	66	·47	·00	Before gale
,, Oct. 13 6 p.m.	Scilly	f d	S	57	58	..	·22	Heavy gale in two days
1884. Jan. 23	Pembroke	f	SSW	50	51	·22	·26	In gale
,, ,,	Prawle Point ..	f	SW	50	*	·23	·08	
,, ,,	Hurst Castle ..	o d f	SW	49	50	·06	·18	
,, May 15 6 p.m.	Pembroke	f	SW	51	52	..	·01	Fog very prevalent about
1885. Feb. 26 6 p.m.	Pembroke	f	SSW	47	48	..	·37	In slight gale
,, Sept. 14 6 p.m.	Pembroke	r f	SSW	59	60	..	·11	Strong SW winds, much fog in Channel
,, Nov. 29	Pembroke	r f	SSW	53	*	·33	·25	Gale in Ireland
1886. Mar. 1 6 p.m.	Hurst Castle ..	d f s	SW	45	*	..	·50	In gale
,, Mar. 26 6 p.m.	Scilly	f d	SSW	51	52	..	·05	In gale
,, ,,	Pembroke	f	SSW	46	47	..	·60	
,, Mar. 27	Pembroke	f	SSW	46	47	·60	·22	
1888. Mar. 8	Holyhead	o f q	SSW	45	48	·05	·20	Before gale
,, ,,	Prawle Point ..	f	SSW	46	48	·12	·20	
,, Mar. 9	Prawle Point ..	f w	SSW	47	48	·20	·04	
,, Mar. 10	Hurst Castle....	f	SW	43	46	·25	·51	In slight gale
,, June 15 6 p.m.	Hurst Castle....	f	WSW	55	56	..	·04	Small depression over South of England
,, Nov. 15	Pembroke	r f g	SSW	54	*	·53	·05	Before and in heavy gale on 16th
,, ,,	Prawle Point ..	r f	SSW	55	56	·08	·07	
,, Nov. 16	Pembroke	c f q	SSW	55	*	·05	·02	
,, ,,	Prawle Point ..	f	SSW	55	56	·07	·02	
,, Dec. 5 6 p.m.	Scilly	f	WSW	55	*	..	·17	In stiff breeze
1889. Feb. 1	Scilly	f	WSW	52	*	·04	·12	Before gale, fog extremely prevalent. See also W. ? Anticyclonic
,, ,,	Holyhead	q f	SSW	49	53	·02	·02	
,, ,,	Hurst Castle....	f	WSW	47	48	·01	·09	
,, ,, 6 p.m.	Dungeness	f	WSW	48	*	..	·00	
,, Aug. 3	Holyhead	f g	SW	59	64	·60	·00	In slight gale
,, ,,	Prawle Point ..	f u	SSW	60	63	·23	·15	
,, Dec. 21 6 p.m.	Scilly	r f	SW	51	53	..	·45	Strong SW winds in Channel
1890. Jan. 9 6 p.m.	Scilly	f p	SW	53	*	..	·12	Strong SW winds in Channel
,, ,,	Prawle Point ..	f	SW	52	*	..	·15	
,, Jan. 13	Pembroke	r f	SSW	50	*	·05	·03	Slight gale
,, June 30	Hurst Castle ..	r f	SSW	56	63	·31	·18	In gale

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CYCLONIC FOGS.

Winds from W to NNW.

Date.	Station.	Weather.	Wind.	Temperature.		Rain.		Notes.
				Min.	Max. Temp.	Preceding.	Succeeding.	
				°	°	In.	In.	
1877. Nov. 21	Pembroke	r f	W	53	*	·28	·21	Preceded heavy gale
1878. Jan. 22	Pembroke	o f	W	51	52	·12	·03	Preceded Westerly gale
1879. Jan. 7 6 p.m.	Scilly	f	WNW	50	52	..	·50	Before and with heavy general SE gale
,, March 5 6 p.m.	Pembroke	f	WNW	45	48	..	·04	Slight SW gale on preceding day
1883. Oct. 7	Sumburgh Head	f	W	53	*	·39	·01	Before W gale in Norway
1889. Jan. 31 6 p.m.	Scilly	f	W	52	*	..	·04	See also WSW
1890 April 7	Dungeness	f	W	46	49	·01	·07	Fresh W winds

ANTICYCLONIC OR DOUBTFUL FOGS.

Winds from E to SSE.

				°	°	In.	In.	
1876. April 7 6 p.m.	Scilly	f	ESE	49	54	..	..	Anticyclone moving off, depression just showing itself
1886. May 22 6 p.m.	Roche's Point .	f	SSE	47	50	..	·35	Outskirts of anticyclone
1887. Jan. 26 6 p.m.	Scilly	o f	SSE	50	*	..	·01	Edge of retreating anticyclone
,, March 3 6 p.m.	Scilly	o f	E	47	48	..	..	Anticyclone, but local depression off South Coast of Ireland
,, March 4	Scilly	o f	E	44	48	..	..	

Winds from S to WSW.

				°	°	In.	In.	
1880. Jan. 5 6 p.m.	Scilly	f d	SSW	51	52	..	·10	Anticyclone
,, March 4 6 p.m.	Pembroke	f	WSW	48	*	..	·02	Doubtful
,, March 5	Pembroke	o f	WSW	48	*	·02	·01	
1881. Mar. 10	Scilly	o f	WSW	50	52	·01	·02	Fog very general. Anticyclone
,, May 6	Pembroke	f	SW	50	*	·01	..	Anticyclonic, but gales in the the North. W 8 Stornoway for 2 days, increasing to W 9, and extending to Wick on 7th
,, Aug. 3	Holyhead	f q	SSW	59	64	·06	..	Doubtful
1882. Mar. 10	Scilly	f	SW	52	55	·02	·03	Anticyclone
,, Aug. 6	Stornoway.....	f	WSW	58	63	..	..	Outskirts of anticyclone
,, Aug. 20 6 p.m.	Scilly	f d	SW	61	63	..	·02	Anticyclonic
1884. Aug. 9	Wick	f	S	56	65	..	..	Possibly anticyclonic
1885. June 18 6 p.m.	Pembroke	f	SSW	54	58	..	·04	Edge of anticyclone
1886. June 14 6 p.m.	Hurst Castle....	f	WSW	55	62	..	·01	Much fog about
1889. Mar. 24	Hurst Castle....	o f d	WSW	45	49	·02	·03	Anticyclonic
1890. June 5	Hurst Castle....	f d	WSW	55	58	·97	·04	Doubtful

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ANTICYCLONIC OR DOUBTFUL FOGS.
Winds from W to NNW.

Date.	Station.	Weather.	Wind.	Temperature.		Rain.		Notes.
				Max. Temp.		Preceding.	Succeeding.	
				°	°	In.	In.	
1877. Feb. 8 6 p.m.	Scilly	f	W	52	53	..	·09	North side of anticyclone
„ July 19	Scilly	f d	W	60	61	·19	·04	North side of anticyclone
1879. Oct. 22	Scilly	o f	W	56	*	·02	·01	Anticyclone
1881. Mar. 10	Jersey	o f r	W	48	51	·01	·01	See also WSW Scilly
„ Aug. 12 6 p.m.	Scilly	r f	W	61	*	..	·25	Anticyclone close by
1887. Jan. 19 6 p.m.	Pembroke	f	W	48	49	..	·27	Edge of anticyclone
1888. Jan. 8	Dungeness.....	f	W	45	50	..	·01	Anticyclone
„ Jan. 22	Scilly	o f	WNW	49	51	·16	·01	Anticyclone coming on

In the preparation of the paper I have received great assistance from Mr. Gaster.

In the column for "maximum temperature" an asterisk indicates that it was the same as that at 8 a.m.

DISCUSSION.

Capt. D. WILSON-BARKER said that he entirely agreed with Mr. Scott's definitions of fog and mist, and had always regarded mist as being more or less moist. Although the fog observations dealt with in the paper had been classified under two heads, viz. cyclonic and anticyclonic, he had no doubt that there was a well marked area between cyclonic and anticyclonic conditions where fogs might be met with.

Staff-Capt. TIZARD said that a better definition of what was comprised in the term "fog" was greatly needed. He noticed that in the tables, snow was entered as accompanying fog at two of the stations. He had never himself observed fog and snow simultaneously, and was inclined to think that the conditions of weather described under the term "fog" in each of these cases was simply a state of the atmosphere which a seaman would describe as "dirty thick weather." The observations used in the tables were all from land stations, and it appeared desirable that these should be compared with such observations on the adjacent seas as might be available. His own idea of fog was that condition of the atmosphere unaccompanied by any precipitation, in which objects at a distance of half a mile were obscured; and he should describe the fog as thick when objects 100 yards distant were not visible. Some scale of fog measurement, by means of the degree of visibility of surrounding objects, seemed necessary.

Mr. C. HARDING said that the weather authorities in the United States issued forecasts of fogs over the banks of Newfoundland, basing their predictions upon the movements of areas of low pressure, it being, of course, evident that when the warm air in the front of a depression met the cooler air over the cold Arctic current flowing over these banks, thick fog must naturally result. Did the term "in a gale," which frequently occurred in the tables accompanying the paper, mean that the fog occurred in a gale, or merely that it was observed in a cyclonic disturbance? He had consulted the charts of the weather over the North Atlantic for each day during the thirteen months, August 1882 to August

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1883, as published by the Meteorological Council, in order to see whether fog usually prevailed when gales were blowing, and had found that it was quite a common occurrence for mist to be observed with gales, especially on the southern side of depressions. As all the stations used in Mr. Scott's investigation were situated on the coast, it appeared desirable to consider the temperature of the sea as well as that of the air.

Mr. F. GASTER said that he hoped this paper would assist in getting rid of the confusion which existed in the use of the terms "fog" and "mist," these terms being intended to describe two distinct classes of phenomena, the one existing with a low temperature, a high barometer, and a calm and dry atmosphere, while the other prevailed when the barometer was low and the temperature high, the wind being strong and the air damp. These two conditions only possessed one common characteristic (that of obscuration), and it was a great mistake to register both phenomena under the same name. As regards the effect of these two varying atmospheric conditions upon the human body, a physician had recently told him that while the one caused excessive irritation of the mucous membrane, the other had no such effect, but was chiefly detrimental to health through producing severe colds. It had probably been often noticed that in an anticyclone, when dry and cold fogs occur, a change would take place without any apparent cause; but he had found, on carefully looking into such instances, that the alteration in atmospheric conditions was brought about by the formation of a very shallow disturbance at the time in the neighbourhood of the district affected.

Mr. R. H. CURTIS thought some confusion was likely to be caused by the way in which the term "dry fog" was used. Disregarding the smoke fogs of London and other large manufacturing towns to which they were peculiar, and which were generally dry and always irritating enough, the fogs which were experienced in rural districts and at sea were invariably composed of water particles, and that being so, it could hardly be correct to call them "dry" under any conditions. It was true that at times these water particles were more minute than at others; and if the fogs were considered simply with respect to their power of wetting surfaces exposed to them, some were relatively dry as compared with others, the fog becoming wetter as its constituent water particles became larger and more numerous, which again was a condition largely due to the temperature of the bodies of air whose commingling was usually the cause of the fog. Mr. Scott had remarked in his paper that the fogs generally occurred with the maximum temperature of the day, but was it not the case that when fog prevailed the temperature was steady and no daily range was apparent?

Mr. G. J. SYMONS said that until Mr. Curtis had spoken he thought he saw a solution of the difficulty of deciding between fog and mist, fog being a dry obscuration of atmosphere, and mist a wet obscuration, consequently "sea fog" would have become "sea mist"; but, as the last speaker rightly said, a dry fog was really a most uncommon occurrence, and was, in fact, an artificial production, so that the settlement of the difference between the phenomena described by the terms "mist" and "fog" appeared to be no nearer than before. Mr. Scott's paper was undoubtedly a valuable piece of work, but hardly concerned London, as all the data referred to seaside stations. Regarding the visibility of objects in fog, he should be glad to know whether the visibility of an object through fog was entirely dependent upon the angle subtended (allowance, of course, being made according to distance and illumination), or whether absolute magnitude had anything to do with it. The degree of visibility during a fog depended on the amount of illumination.

Mr. H. N. DICKSON said that there appeared to be a simple physical explanation of the difference between mist and fog. In fog, vapour was condensed on dust nuclei from an unsaturated atmosphere in sufficient amount to make the particles visible. London fog required little vapour for its formation, for the dust particles were originally large and easily cooled by radiation, and a slight increase of size was sufficient. At sea the dust particles were saline and attracted moisture. When the air was saturated or nearly so the fog particles had each an increased allowance of water, and parted with it to surrounding objects, the characteristic of mist.

Mr. R. H. SCOTT in reply said that the observations of fog were taken as re-

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ported by the observers in the *Daily Weather Report* at 8 a.m. and 6 p.m. It was a difficult matter to consider fogs in relation to the centres of cyclones and anticyclones, as it could not frequently be determined where the cyclone began and where the anticyclone ended. No ships' logs had been taken into consideration, and, in fact, there were very few observations from ships' logs close to the coasts, as many ships did not commence to keep logs until quite clear of the British Islands. A scale of visibility of objects at known distances, for the purpose of measuring the amount of fog obscuration, had been arranged at the Kew Observatory and carried on for two years, but some difficulty, chiefly due to unequal illumination, had been experienced in making observations. The objects observable were also all situated in directions from north-west round by east to south-east; the rest of the horizon being limited by Richmond Hill or by trees. As regards the issue of forecasts of fog for the banks of Newfoundland, it must be remembered that there was no similar condition of ocean currents prevailing in the seas round the British Isles as was the case at Newfoundland. The note "in a gale," to which Mr. C. Harding had drawn attention, was intended to mean that a wind force of 7 or 8 was observed somewhere in the British Islands at the time of the occurrence of the fog. As regarded the use of sea temperatures in connection with this investigation, very few satisfactory and trustworthy observations of sea temperature were available, and he (Mr. Scott) did not anticipate that sudden changes of sea temperature would be found to occur.

SOME CHARACTERISTIC FEATURES OF GALES AND STRONG WINDS.

By RICHARD H. CURTIS, F.R.Met.Soc.

(Plate V.)

[Received June 5th.—Read June 20th, 1894.]

There is probably no branch of meteorology about which so little is really known as wind measurement, and yet there is no other which is of more general importance or which is more far-reaching in its bearings upon other branches of the science. But directly we get beyond the general statement that wind is a result of solar action, and ask more particularly as to the causes by which its infinitely varied movements are determined and governed, we find ourselves in a domain in which theory abounds, but in which ascertained facts are conspicuously rare. We know, for example, that some relation exists between barometrical gradients and wind force, but of the causes which produce those gradients, and modify them, by varying the intensity of areas of high or low pressure, we know scarcely anything at all. And not only is this true as regards the broader features of the subject, but it is so also with respect to details as to which it might have been supposed that meteorologists would long ago have found out all that was to be known. For years we have had all over the country an army of observers, most of whom are

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enthusiastic and intelligent, and yet after all they have done we still know next to nothing as to the manner in which the wind blows, of its strength or velocity, of the nature of its pulsations, its squalls and its lulls, or of the way in which its dynamic force is exerted upon obstacles opposed to its path.

Or if we look at our instrumental appliances for obtaining information on these points, we find a state of things which may fairly enough be termed chaotic. We still use without comment appliances yielding results which are at least doubtful to a very high degree; we put our anemometers up on sites which we know are fatal to their integrity; and quietly ignoring ascertained facts respecting them, we still use the results obtained from instruments of different patterns, and known to be in their present state non-comparable, as if they all meant one and the same thing.

I have long felt it to be a fair matter of reproach to meteorologists, that while this is the state of the case so little effort should be made to remedy it. Of course I know perfectly well the inherent difficulties in the way of advance in certain directions—perhaps no one knows them better,—but still there are some branches of the subject in which I venture to think that very much might be done by intelligent observers, even without elaborate mechanical appliances, if only systematic and thoughtful attention were given to them.

I have mentioned these matters, since they afford the reason why I have brought the present paper before the Society, for they appear to me to justify one in making any contribution, however small, to our knowledge of a subject about which so little is known.

In a paper[1] which I read before the Society in 1881, I drew attention to the evidence of very high velocities of wind which was afforded by the traces obtained from the Robinson Cup Anemometers at some exposed stations. I pointed out that although the records of that class of instrument were not well suited for giving velocities for short periods, owing to the great reduction

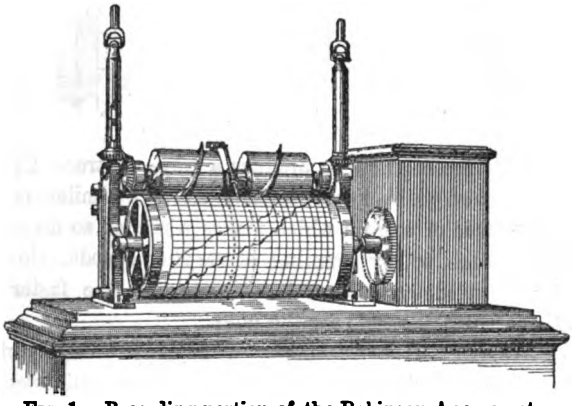

FIG. 1.—Recording portion of the Robinson Anemometer.

which the revolutions of the cups underwent before registration, yet the traces often showed decided angular changes which clearly indicated that large increases of velocity took place, but which, lasting only for a short time, were

[1] *Quarterly Journal*, Vol. VII. p. 205.

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not recognisable in the general result obtained when the run of the cups over sixty consecutive minutes was measured, as is usually done in tabulating the records. In the large size Anemometer, with 9 inch cups and arms of 2 feet radius, the recording portion of which is shown in fig. 1, 7,000 revo-

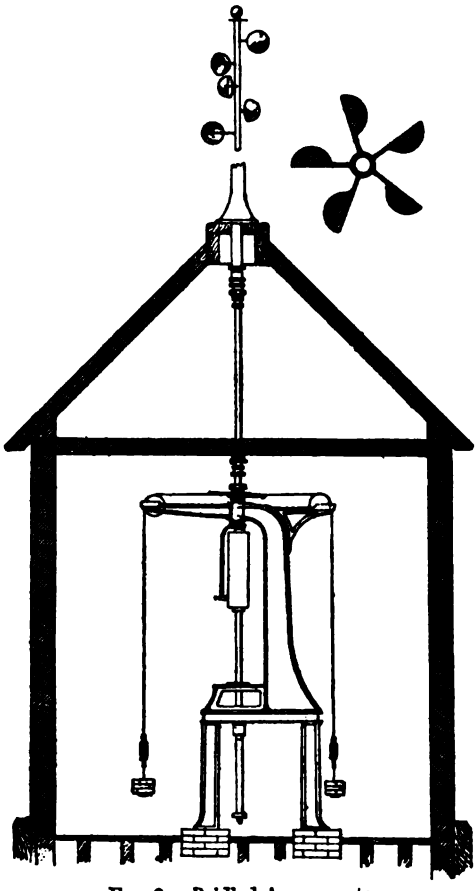

Fig. 2.—Bridled Anemometer.

lutions of the cups are required to produce a piece of trace 2¾ inches long, representing the passage over the instrument of 50 miles of wind. The case is similar to that of a train which makes a run of so many miles in an hour, but which does so by running at varying speeds, slowly up steep inclines and rapidly down others, the slower and the faster rates being merged in the actual nett result for the hour.

Since then I have had opportunities of more thoroughly studying this subject from other points of view, and I wish now to call attention to some conclusions I have obtained, mainly from a study of the records yielded by the Bridled Anemometer, devised by Sir George G. Stokes, F.R.S., and erected by the Meteorological Council at Holyhead.

The construction of this instrument will be understood by a reference to fig. 2. It consists of five hemispherical cups attached by short arms to a

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vertical spindle, upon which they are arranged spirally and in such a way that no cup shall interfere with the one immediately behind it. The cups and spindle are not free to revolve with the wind, as in the case of the Robinson instrument, for their movement is checked by weights which have to be lifted as the spindle revolves, and the amount of torsion of the spindle is therefore the measure of the wind's force. The instrument, it will be seen, belongs to the class of pressure anemometers; but since the pressure varies as the square of the velocity, it has been designed so as to give an equal scale of velocity throughout. A large cylinder carries a sheet of paper which receives a record of every movement of the cups, and there is an arrangement by which the time-scale, which is normally seven-tenths of an inch to the hour, can be doubled, or if desired enlarged to about 48 times its normal size, or even more.

With the most open scale it is possible to follow every movement of the wind, and to obtain a good deal of insight into the manner of its working, but with the normal scale the gusts in gales of wind follow each other in such quick succession that the pencil produces a broad band of shading extending over some miles on either side of the average velocity, and it is only the gusts and lulls which extend beyond this belt which can be singled out from the others.

This instrument throws a considerable amount of light upon the question of maximum velocities to which I just now referred. For the reasons I have mentioned it is of course almost impossible to correlate individual gusts with the indications of increased velocities shown on the Robinson curves, but it is possible to do so with *groups of gusts*, and the comparisons of the two which I have made show that the estimates quoted in my paper were not far from the truth, when a proper allowance has been made for the fact that they were based on the assumption that Dr. Robinson's original factor (3), for the relation between the motion of the cups and that of the wind, was correct. I may mention that the scale of the Bridled Anemometer is based upon data recently obtained by Mr. Dines, and it will be remembered that other of his experiments led him to conclude that the factor (3) was about 30 per cent. too large.

The highest force of an individual gust that I have met with on the Bridled Anemometer was registered in December 1891, and amounted to a rate of 115 miles per hour, which with the old factor would be equivalent to a rate of about 150 miles per hour. Gusts at a rate of from 90 to 100 miles per hour have many times been recorded, but the usual limit for gusts in a strong gale may be taken to equal about 80 miles per hour, which on the old scale would be equivalent to about 120 miles per hour. It is necessary to bear in mind these old scale equivalents, because it is with them that the maxima formerly quoted must be compared.

The record obtained from the Robinson instrument will depend very much upon the character of the wind, and for this reason it is not always a very safe guide in forming a judgment as to the intensity of a gale. If a high hourly mileage is registered there can be no doubt that a very strong wind

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must have prevailed to produce it, and yet it is possible that an even more destructive and dangerous wind should have prevailed with a smaller mileage indicated by the instrument; indeed, I have come to the conclusion that whilst the positive evidence of the Robinson instrument is valuable, its negative evidence must be accepted with the greatest caution, and is indeed worth little. These records are sometimes produced in Courts of Law as evidence when litigants wish to show that a gale did or did not prevail; in the latter case it would be only necessary to ask whether a heavy transient squall could not have occurred without its being indicated upon the trace in order to destroy entirely its value as evidence upon the point.

As a matter of fact, gales differ in character very much, as indeed do also winds which do not attain the strength of a gale. As the result of a prolonged study of their general features, as recorded by the bridled anemometer, I have for my own use divided them into three general classes, within which there are, of course, some fairly wide limits for variety.

In the first class I place those gales which are essentially *squally* in character—in which the gusts constitute the main feature of the gale. In such a case the gusts and lulls alternate very rapidly, and indeed the wind is never constant in force for many seconds together. Usually it oscillates over a range of perhaps 10 or 20 miles at a mean strength of probably 40 miles per hour, but every now and again it bursts out with a velocity of possibly 40 or 50 miles an hour above the average, and after a few seconds sinks to a rate of 10 or 20 miles below it. This is certainly the most usual character of the gales experienced on our coasts, although such gales vary immensely as regards the strength and frequency of the gusts and lulls, and also as to the average velocity of what may be called the "normal of the gale."

The trace which the bridled anemometer would make in such a gale may be thus described. At that part of the scale indicating a velocity of (say) 30 to 40 miles per hour there will be a band of flat shading, caused by the innumerable passages backwards and forwards of the pencil as it ranged over those limits with the oscillations of the wind, this is what I have termed the "normal of the gale;" above this band will be a less dark fringe, passing off into more or less isolated lines, made by the stronger gusts which have carried the pencil beyond the usual limits; while every here and there, at intervals of perhaps a few minutes, lines will start up, generally two or three quite close together, far above any others, marking the extreme limits of the gale. At the bottom of the belt of shading a similar appearance will be found caused by the lulls succeeding the gusts, but generally extending over a much more limited range of velocity. Fig. 1 (Plate V.) is a reduced reproduction of a portion of the record of such a gale, in which, however, the "normal" is much higher, whilst the range of the gusts above it is less, than is commonly the case.

The frequency with which the gusts follow each other varies, as I have said, immensely. I have, however, made an attempt to count them in cases where the use of the most open time-scale would allow of my doing so, and I think I may say that in an average gale the ordinary gusts follow each other at in-

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tervals of about 10 to 20 seconds, while the extreme gusts occur at the rate of about one per minute. I only put this forward, however, as an approximation for the case of an average gale.

The range of velocity covered by the squalls is another point upon which gales differ very largely. In those to which I am now referring—squally gales—a range in rate of from 40 to 50 miles per hour above the "normal" is common, and may, I think, be regarded as a fair range for the extreme gusts in a fairly strong gale, while in a similar gale a total range of rate, from the lull to the following squall, of from 60 to 70 miles, or even more, is not unusual.

My second class of gales are those in which the velocity of the wind is tolerably steady, much steadier than in the first. The "normal" of the gale covers a much smaller range, perhaps not more than a rate of five or six miles per hour, and the gusts are far less severe; and I have noticed that generally they are not accompanied by lulls falling much below the "normal," or if the lulls are frequent then the gusts above the "normal" are comparatively few. This is a rather curious feature, but I have noticed it in several cases. Figs. 2 and 5 (Plate V.) are reduced facsimiles of portions of traces produced by gales of this class, the time-scale used in fig. 5 being a very open one.

The trace in this instance would be very different from that I have just described. The band of shading is much narrower, and as a rule far less flat, whilst the isolated lines above or below are much shorter and perhaps less numerous. It does, however, sometimes happen that the "normal" is even higher than in some of the more violent squally gales.

My third class should perhaps have been the second, inasmuch as it is a distinctly squally variety of gale. But the characteristic by which I distinguish it is peculiar. The record made by the anemometer has *two* "normals," connected by a lighter band of shading, as shown in fig. 3 (Plate V.). Indeed the gale appears to be made up of two series of rapidly succeeding squalls, the one series at a comparatively low rate of velocity, the other at a much higher one, the wind-force shifting rapidly and very frequently from the one series to the other. Examples of this class of gale are not very common, but those I have seen have been very well marked.

The trace in this case would show a very broad band of shading, with the upper and lower limits much darker than the centre, and having a good many isolated lines indicating gusts of considerable intensity projecting above the upper limit.

Before leaving the subject of gusts there are two other points to which I would like to call attention, and the first is as to their *duration*. As I have already said, the bridled anemometer is provided with an arrangement by which a time-scale of about ½ an inch to the minute can be used, and when this is in use in a gale of wind the duration of the gusts can be very fairly judged. In many instances they are very sudden in their occurrence; the rate rises to the maximum with great rapidity, remains there but an instant, and falls back again as quickly; the whole thing lasting but a second

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or so. In many cases, however, it is different. I find with the bridled anemometer the same thing as I have since witnessed, times without number, with Mr. Dines's pressure tube anemometer, and which is the second point I wish to mention. The gust does not rise to its maximum at one bound. The pen or pencil rises some distance, then pauses, and perhaps recedes slightly, it then starts upwards again, and perhaps makes another pause before it finally reaches its maximum. When there it seldom rests long, but falls again as it rose, in stages, and I have measured many cases in which the gust remained at about its maximum, falling and rising 2 or 3 miles only, for several seconds; indeed, in one case, of which I have a note, it did so for more than half a minute, during the whole of which interval the velocity did not vary more than 6 miles. The action of the instrument under the influence of gusts and lulls is well shown in figs. 4 and 5 (Plate V.), in both of which an open time-scale was used.

The only other point to which I wish now to refer is one to which I do not think attention has been called before. On looking carefully over these records I have found, oftentimes very distinctly marked, a long pulsation in the wind force which recurs again and again with more or less regularity at intervals of perhaps 20 minutes or half-an-hour in some cases, and in others at longer intervals of about an hour, more or less. What I have before termed the "normal of the wind force" rises gradually, and as gradually subsides again; the quicker and larger oscillations of gusts and lulls going on all the while and quite independently of this long period oscillation. In some cases this phenomenon is more marked than in others, but it is very common, and I am inclined to think that in many instances where it is not very apparent its absence is due really to the more casual oscillations having in some way obliterated it.

Generally it is best seen on the traces by foreshortening them somewhat, and so getting a more generalised view of them, but in plenty of instances it stands out, as in fig. 6 (Plate V.), evident enough without doing this. The most violent gales are not those in which it is best seen; a moderate gale, or a strong wind which falls just short of the strength of a gale, are perhaps the cases in which it shows itself most evidently. When the gusts and lulls very rapidly succeed each other, and at the same time cover a wide range, it is less apparent without foreshortening. This feature of the wind-force is also shown very distinctly on the curves yielded by Mr. Dines's new pressure tube anemometer; and the regularity with which it recurs throughout the whole continuance of a gale, as well as the fact that it is of such common occurrence, leads me to think that it very probably plays an important part in the general movement of large masses of air, such as are involved in gales of wind, and that it is a phenomenon well worthy of further investigation.

The phenomenon is not to be confused with the passing gust which comes and goes in a few seconds, and in which the velocity probably rises considerably before it dies away again. In the case of the long pulsation the increase in the "normal" is always gradual, and may be very slight,

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although very evident, and the pulsation is certainly not shown in the hourly measurements of velocity, owing to the fact that its period is fairly uniform, and therefore its effect becomes distributed pretty equally.

In conclusion, I beg to express my thanks to the Council of the Meteorological Office for their permission to make use of the curves of the Bridled Anemometer for the purposes of the paper.

DISCUSSION.

Mr. W. H. DINES said that he quite agreed with everything Mr. Curtis had said with reference to the chaotic state of anemometry, and as an instance he might mention the way in which the hand rail of the ladder by which the observer got up to the cups was sometimes left projecting, so that the eddy from it would just catch one side of the instrument as it turned. He was glad Mr. Curtis had based his results upon the Bridled Anemometer at Holyhead, as he thought that was the only trustworthy pressure instrument from which we had any records in England. He might state that he had constructed a scale for this anemometer at the request of the Meteorological Council. The identical cups now in use at Holyhead had been sent to him, and he had tried them at speeds up to 70 miles an hour upon the whirling machine at Hersham. The velocities quoted by Mr. Curtis were therefore quite independent of any question about the value of the factor of the Robinson cups. He had obtained the pressure upon a square foot circular plate on the same whirling machine, and by precisely similar methods, and hence he could state positively that the highest wind pressure ever recorded at Holyhead was about 36 lbs. per square foot, corresponding to Mr. Curtis's 115 miles per hour, and about 20 lbs. would correspond to the gusts of 80 miles per hour. This was remarkable, since Holyhead was one of the windiest stations in the British Isles, yet pressures of 30 lbs. were quite common at many other stations inland, Bidston particularly, where 90 lbs. per square foot had been registered. He thought it was explained by the fact that the Bridled Anemometer was trustworthy, whereas the records of the pressure plates were utterly unreliable in so far as maximum pressure was concerned, on account of the unsatisfactory way in which the pencil was connected with the plate. Mr. Curtis had found that with an average or "normal' velocity of 40 miles per hour, a maximum of 80 or 90 might be expected in the gusts. At Oxshott he had found that the maximum was generally about double what Mr. Curtis called the normal velocity, and the relation seemed to hold for light as well as strong winds. It was noteworthy, however, that when the temperature was high the wind was always more gusty, also at Oxshott the South-south-west and North-west to North winds were especially gusty, but this was probably due to the fact that to the south-south-west and north-north-west there were trees within 100 yards nearly level with the anemometer, while in all other directions there was a very good exposure.

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PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

May 16th, 1894.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

LEONARD BUCKELEY WILLIAMS, M.B., Ch.M., Hillsdon, Sidmouth, was balloted for and duly elected a Fellow of the Society.

The following communications were read:—

"THE RELATIVE FREQUENCY OF DIFFERENT VELOCITIES OF WIND." By WILLIAM ELLIS, F.R.S. (p. 287.)

"AUDIBILITY OF 'BIG BEN' AT WEST NORWOOD UNDER CERTAIN METEOROLOGICAL CONDITIONS." By W. MARRIOTT, F.R.Met.Soc. (p. 248.)

"EARTH TEMPERATURES AT CRONKBOURNE, ISLE OF MAN, 1880-1889." By A. W. MOORE, M.A. (p. 250.)

"NOTE ON A DUST WHIRL OR WHIRLWIND AT ADDISCOMBE, APRIL 22ND, 1894." By P. BICKNELL, F.R.Met.Soc.

ON Sunday, April 22nd, 1894, between 2.30 and 2.31 p.m., I, and two friends walking with me, saw a whirlwind or dust whirl close to Addiscombe Road Station.

It was calm, or almost calm, when we saw a sudden cloud of dust almost at the corner of Canning Road. The cloud collected opposite the railway station, and a thin column of dust ascended from that point to a height of 60 to 100 yards, at first perpendicularly, and then turning to the north. The lower part of the whirl, rotating with the sun, advanced along the Addiscombe Road for some 80 yards, then turning the corner of Canning Road and being lost to sight.

Any light breeze there was was from about East-south-east, but it was *very nearly* calm all round, and I particularly noticed that the leaves of the trees close to the course of the whirl were quite still.

The ascending dust looked just like yellow smoke rising from a chimney on a perfectly calm day, but, of course, it rose much higher.

Though I never saw such a phenomenon before, I presume it is of frequent occurrence.

MR. G. J. SYMONS, F.R.S., exhibited three lantern slides of SNOW CRYSTALS.

June 20th, 1894.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

The following communications were read:—

"FOGS REPORTED WITH STRONG WINDS DURING THE 15 YEARS 1876-90 IN THE BRITISH ISLES." By ROBERT H. SCOTT, F.R.S. (p. 253.)

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"SOME CHARACTERISTIC FEATURES OF GALES AND STRONG WINDS. By R. H. CURTIS, F.R.Met.Soc. (p] 262.)

MR. R. H. SCOTT read the following:—

"NOTE ON TWO OCCURRENCES OF GLOBULAR LIGHTNING IN WARWICKSHIRE"

I HAVE received from my brother, Mr. E. A. Scott, M.A., one of the Masters of Rugby, a note stating that at about 11 a.m. on Thursday, April 26th, 1894, during a hailstorm, he saw a ball of fire "about as large as would go into a stable bucket" touch a tree close to his house at Rugby and explode. The lightning scathed the bark on both sides, "covering the road and one walk with outer bark (elm) stripped off."

Apparently this fire ball was not seen until immediately before its explosion.

The other occurrence took place on Sunday, July 2nd, 1893, at Dunchurch, near Rugby, and is described in *Nature*, Vol. XLVIII., at p. 341, in a letter from Mr. L. Cummings, M.A., another of the Rugby Masters. Mr. Cummings says, "I was enabled to examine four witnesses, all of whom agree that during an interval of two minutes before the explosion a large fiery globe was seen travelling through the air, and emitting light of such dazzling brilliancy that the only one of them who was out of doors at the time was for a moment blinded and dazed, and felt for some short time afterwards a sensation of pain in the back of the head and the neck.

"The path taken by the fireball during the two minutes it was observed could hardly have been direct, as the direction taken when first seen makes an obtuse angle with the direction indicated by all who saw it immediately before the explosion.

"The damage done was the fracture of 24 panes of glass in the house, and the breaking off, at a height of 17 feet from the ground, of the top of a Wellingtonia some 30 feet high, and distant 23 yards from the nearest corner of the house."

MR. R. H. SCOTT read the subjoined letter from a correspondent in the Philippine Islands on the subject of the dependence on atmospheric conditions of the motion of the smoke of volcanoes.

In the *Proceedings of the Royal Society*, Vol. XLIII., the Hon. R. Abercromby gives two sketches of the smoke column, (1) in fine weather, and (2) before a typhoon, of the "volcano of Abayon in the Island of Albay." This should read the "volcano of Mayon, near Albay, at the southern end of the Island of Luzon." The letter confirms, in the main, Mr. Abercromby's remarks.

"DEAR SIR,—My friend, Mr. F. E. Coney, has written me from England asking me to write you direct any information I could supply you with in regard to the smoke issuing from the volcano of Mayon. I can say nothing from personal observation, but two gentlemen here who lived at Tobaco, a town situated at the base of the mountain, inform me that during fine weather the smoke ascends straight. During, or rather before, bad weather, the smoke descends, forming a cap all round the summit, not only on one side as the sketch Mr. Coney sent me suggests. The distance which the smoke descends varies according to the density of the atmosphere. It is not necessary that a typhoon should follow; a strong blow from the South will cause this. Neither gentleman can state certainly that they have ever seen this "cap" half way down, but certainly quite one-third. But they think that before a heavy typhoon, with an abnormally low barometer, the mountain may be half covered.

"I trust this information will be of use to you. If there is any other information which you may require which I can obtain for you, please make use of my services.—I am, dear Sir, faithfully yours, D. M. FLEMING. Manila, 15th May, 1894."

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CORRESPONDENCE AND NOTES.

Dew and Sea Breeze.—Mr. S. Knott, in a letter to Mr. R. H. Scott, F.R.S., dated Mojanga, Madagascar, July 24th, 1894, says: "When visiting you over a year ago you asked me if heavy dew brought rain, to which I replied in the negative. This season I have carefully watched the after effects of dew, and find that during the present monsoon (S.E.) heavy dew invariably brings a change of wind in the afternoon of the day following, or here a sea breeze from North-west to South-west; and, curiously, the heavier the dew the stronger the sea breeze. And further, during this monsoon I find that these heavy dews and sea breezes occur at the spring tides, and the monsoon is much lighter during these 12 days; but when the neaps take on it increases very much in force, and only varies from due South to South-east."

Rainfall at Sevenoaks.—Mr. W. W. Wagstaffe, having completed ten years' residence at Sevenoaks, has forwarded the following results of his rainfall observations:—

RAINFALL AT SEVENOAKS, 1884-93.

Years.	Jan. in.	Feb. in.	Mar. in.	April. in.	May. in.	June. in.	July. in.	Aug. in.	Sept. in.	Oct. in.	Nov. in.	Dec. in.	Total. in.
1884.....	2·48	1·95	1·93	1·63	·74	1·64	1·93	·93	4·97	1·74	·82	3·80	24·56
1885.....	2·13	3·03	1·65	2·50	3·88	1·29	·25	1·15	4·73	4·32	2·85	1·76	29·56
1886.....	3·21	·58	1·66	2·17	4·08	·54	2·77	1·64	2·50	2·77	4·24	4·28	30·44
1887.....	2·89	·52	1·68	2·43	2·00	1·26	·99	2·62	2·38	2·23	4·73	2·10	25·82
1888.....	·72	1·80	4·59	2·16	1·19	5·92	5·31	3·31	1·59	1·70	4·96	2·20	35·45
1889.....	1·22	3·23	2·54	3·20	3·00	1·90	2·60	2·65	1·55	6·10	1·56	2·19	31·74
1890.....	3·75	1·21	3·14	2·70	1·73	2·25	5·46	3·95	·72	1·37	3·53	·56	30 37
1891.....	3·34	.....	2·19	·72	3·76	1·84	4·52	4·51	1·69	7·70	2·98	4·36	37 61
1892.....	·86	1·65	2·07	2·07	1·17	5·40	2·55	3·96	2·82	5·94	4·16	2·67	35·34
1893.....	2·80	4·33	·73	·01	·46	·77	3·23	1·07	1·91	4·86	3·19	2·92	26·27
Means ...	2·34	1·83	2·22	1·96	2·20	2·28	2·96	2·57	2·49	3·87	3·30	2·68	30·70

The greatest fall on one day was 2·63 ins. on June 28th, 1892.

Mr. Wagstaffe recorded the rainfall twice daily, viz. at 10 a.m. and at sunset, with the view of seeing what an "invalid's day and night" would show in the difference of rainfall; the invalid's day being taken to be from 10 a.m. to sunset. The percentage of rain which fell in the former period, compared with that which fell in the latter period, was as follows:—

	Day	Night		Day	Night
January	37	63	July	48	52
February	39	61	August	42	58
March	35	65	September	37	63
April	38	62	October	42	58
May	40	60	November	35	65
June	43	57	December	41	59

[The division of the 24 hours into two periods, 10 a.m. to sunset and sunset to 10 a.m., may be interesting from the point of view of the valetudinarian, but it is otherwise an arbitrary and artificial division, one having no meteorological significance, and no relation with any physical fact, such as, for instance, would have been the case had the limiting times been sunrise and sunset. The varying percentages found for different months must largely depend on the difference in the length of the adopted day at different seasons, rather than on any real variation in the daily distribution of rainfall. So that the conclusions of the author have no meaning in a meteorological sense, as between day and night, but only as referring to the division of the day adopted.—ED.]

Radii to a Rainbow.—Mr. H. C. Russell, F.R.S., of the Sydney Observatory, New South Wales, has forwarded the accompanying sketch made by Mr. L.

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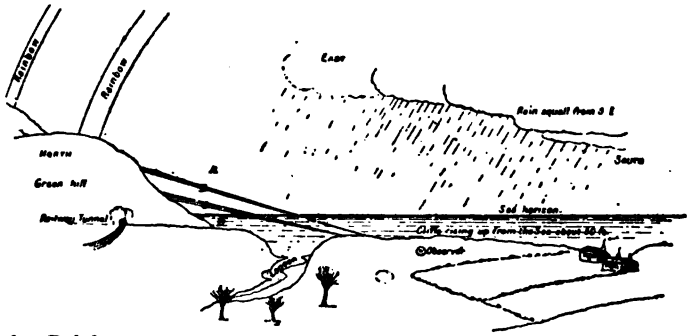
Hargrave of two well-defined radii of a rainbow, which he observed at Stanwell Park, 20 miles south of Sydney, at 5 p.m. on May 9th, 1894. The radii remained visible for 10 minutes.



Radii of a Rainbow. A. Dust colour. B. White radius. C. Light slate coloured radius. D. Dark slate colour.

Protection from Lightning.—The U.S. Weather Bureau has issued a pamphlet on this subject by Mr. A. McAdie, which is intended to furnish information of practical value to all classes, and especially to farmers, builders, and physicians. The author gives statistics of deaths, fires, and damage caused by lightning, and shows that barns, granaries, and stables are the objects most frequently struck. The risk in the country is about five times greater than in the city. With regard to trees, the oak is most frequently, and the beech least frequently struck. The author mentions various methods recommended for protection from lightning, and describes the *Report of the Lightning Rod Conference* as an excellent one, and that it must stand for years as the embodiment of the most widely gathered information and well considered decisions. Mr. McAdie points out that there are some very prevalent misapprehensions with regard to lightning. For example: that it never strikes twice in the same place; that the most exposed place is always struck; that a few inches of glass or a few feet of air will serve as a competent insulator to bar the progress of a flash that has forced its way through a thousand feet of air, &c. The author then proceeds to give some practical rules for guidance in selecting and maintaining lightning conductors, the last of which is as follows:—"Finally, if you should be in the vicinity of a person who has just been struck by lightning, no matter if the person struck appears to be dead, go to work at once and try to restore consciousness. There are many cases on record proving the wisdom of this course; and there is reason for believing that lightning often brings about suspended animation rather than somatic death. Try to stimulate the respiration and circulation. Do not cease in the effort to restore animation in less than one hour's time."

Remarkable Hail.—During a severe hailstorm at Vicksburg on the afternoon of Friday, May 11th, a remarkably large hailstone was found to have a solid nucleus, consisting of a piece of alabaster from one-half to three-quarters of an inch. During the same storm, at Borina, 8 miles east of Vicksburg, a gopher turtle, 6 by 8 inches, and entirely encased in ice, fell with the hail.

An examination of the weather map shows that these hailstorms occurred on the south side of a region of cold Northerly winds, and were but a small portion of a series of similar storms; apparently some special local whirls or gusts carried heavy objects from the earth's surface up to the cloud region, where they were encased by successive layers of snow and ice, until they fell as hailstones. The fact that hailstones, as well as drops of water and flakes of snow, often contain nuclei that must have been carried up from the earth's surface, is entirely in accord with the general principle that ascending currents precede the formation of cloud and rain, and that solid nuclei are needed to initiate the ordinary precipitation of moisture.—*Monthly Weather Review*, May 1894.

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The Weight of Snow.—Prof. Cleveland Abbe, in the *Monthly Weather Review* for April, gives the following notes on the weight of snow:—"In connection with the heavy snowfall of April 10th and 14th, in Pennsylvania, N. 41°, W. 77° 40', the amount of snow that fell on the platform scales at that place weighed 1,640 pounds; as the platform was 8 by 12 feet, or 96 square feet in area, this gives an average weight of about 17 pounds to a square foot, which is equivalent to a depth of 3·3 inches of water, and using the ordinary ratio, 10, this gives a corresponding depth of 33 inches of snow.

"Mr. Edward Ferry, of Bel Air, Harford Co., Md., in a letter published in the monthly report of the Maryland State Weather Service, states that his clerk found that the weight of the snow on the platform scales at that place was 1,520 pounds (presumably on the morning of April 12th); the scale platform measured 7 feet 10 inches by 15 feet; this gives an average of 12·93 pounds to the square foot, and, if we assume that none of the snow melted, and so escaped being weighed, this would correspond to a depth of 2·4 inches of water. The average depth of snow lying on the ground at the end of the great snowstorm of April 10th and 11th, in Northern Maryland, varied from 15 to 30 inches in the different localities covered by newspaper reports, but the largest recorded by regular observers was 24 inches at Darlington and at Fallston, both in Harford County, at the head of Chesapeake Bay.

"Although the above result may be rather crude, yet it suggests an excellent method of getting at the average quantity of precipitation in case the snow falls without melting and without much drifting. It also gives some idea of the weight that must be supported by roofs and walls in cases of similar heavy snowfalls.

Climate of Algeria.—Mr. A. S. White, in a paper on "The Situation in Algeria" (*Scottish Geographical Magazine*, April 1894), gives a brief account of its climate. The paper is admirably illustrated by maps showing the vegetation and surface features; orographical features; mean annual temperature; and mean annual rainfall. The climate and vegetation of Algeria approximate to those of southern Europe, but are more sub-tropical in character. The average annual rainfall of Algeria is sometimes taken at 29 ins. The highest rainfall (over 51 ins.) is recorded in the Jujura mountains, to the east of Algiers; the lowest, of course, in the Desert. The intervening regions receive, roughly, from 28 to 31 ins. on the northern slopes of the Atlas, and from 15 to 23 ins. on the southern slopes. On the borderland of the Desert there is an annual rainfall of from 7 to 15 ins. Algeria suffers very much by the absence of important rivers, and the prolonged drought in the summer; but extensive irrigation works (costing nearly five millions of francs) have been undertaken to remedy these defects, whilst in the south especially at the base of the mountains, there are inexhaustible supplies of subterranean waters. Coincidding with the systems of climate, there are well marked and diversified characteristics of soil. Broadly speaking there are three distinctive regions: the *Tell* lands of the Littoral, the High Plateau, and the Saharan or Desert tracts. The vine, cereals, olives and oranges are cultivated in the *Tell*, cereals and *alfa* are raised on the High Plateau; and in the Desert regions date-palms and fruit trees bear fruit in the summer, whilst in the winter flocks and herds occupy the attention of the inhabitants.

Observations on Mount Ontake, Japan.—A party of observers set out in July 1891 from the Tokio Observatory to make a series of two-hourly observations on the summit and at the base of Mount Ontake, which is one of the highest mountains in Japan, being 10,023 feet above sea level. The observations extended from August 1st to September 12th, a period of 43 days. The results are published in the *Annual Report* of the Central Meteorological Observatory of Japan for 1891, part II. The mean atmospheric pressure on the summit during this period was 20·94 ins., which is only seven-tenths of that at sea level. The slightest labour soon caused fatigue, and breathing was greatly accelerated. The mean temperature of the air, though it was the hottest season of the year, was only 48°, which corresponds to the latter part of March or the middle of November in Tokio. Towards the end of August water, kept in a

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tank placed outside the cottage, froze to a thickness of about 0·24 in. This, however, was said to be an unusual occurrence at this season; the minimum temperature on the 27th was 47° even at Kurosawa, the lower station (2,733 feet above sea level). As it is so cold on the summit great masses of snow remain unmelted in several shaded places even during midsummer. When clear days continued for a long time, as was the case in the first part of September, the temperature of the air generally rose above 68° by day, and even at night it remained above 41°. Anyone who exposed himself on such days to the direct sunshine felt its scorching effect upon the skin to be almost intolerable, owing to the great rarefaction of the atmosphere and the smallness of the amount of aqueous vapour in it.

When an area of low barometer passes near the mountain, the summit is enveloped in dense clouds with heavy wind and cold rain, which carry off the heat from the human body very quickly. In such cases climbers often lose their way, and are sometimes chilled to death.

During the period in question the temperature of the air during the days of storms remained almost stationary at 48° or little above, when the cold was felt to be more intense than in the calm dry days with lower temperature.

Climate of Alaska.—Mr. J. C. Russell, in a paper on "Alaska: its physical geography," in the *Scottish Geographical Magazine* for August, says that the climate of Alaska, like its physical features, presents marked contrasts. On the south coast the rainfall is excessive, amounting in some observed instances to more than 100 inches a year. A series of observations made at Sitka by Russian observers for 20 years gave a mean annual precipitation of over 83 inches. A belt of extreme humidity extends westward along the coast, probably increasing in breadth until Mount St. Elias is reached, and then diminishing in the vicinity of the Aleutian Islands. In the interior it is much drier, as is known from the experience of travellers, and also from a limited number of observations. At Camp Davidson, where the Yukon crosses the 141st meridian, as observed by Mr. M'Grath, of the U.S. Coast and Geodetic Survey, the precipitation from September 14, 1889, to June 22, 1891, was but 19·05 ins.; for the year 1890 it was 13·55 ins. On the northern coast, in common with other portions of the Arctic zone, the annual precipitation is small; at Point Barrow, as observed by the International Polar Expedition in charge of Lieutenant Ray, the rainfall for 1882 was a little over 8 inches.

The aridness of the interior and northern portion of Alaska may thus be compared with that of the arid region between the Rocky Mountains and the Sierra Nevada. The humid region along the south coast is a continuation of the rainy belt of Oregon and Washington. The excessive rainfall on the southern coast is accompanied by cool summers and by remarkably mild winters. The mean annual temperature at Juneau and Sitka is about 50°. The temperature seldom falls below zero (0°). The winters are milder than at Chicago or Boston, and are not marked by the extremes experienced in New York or Washington. In the interior the summers are warm, and occasionally the temperature rises to between 90° and 100° in the shade; but in winter the cold is excessive, and a temperature 40° or 50° below freezing point is frequently experienced for many days in succession. The difference in climate between the coast and the interior is, perhaps, most strongly indicated by the character of the vegetation. On the east coast of Mount St. Elias the forests are dense, the trees are large, and the undergrowth nearly as impenetrable as in the Tropics. In the interior the forests are almost entirely of spruce trees of small growth, which are confined to the river valleys, while the hill tops and mountain sides are bare of trees and covered with luxuriant grasses.

The marked climatic differences between the coast and the interior also find expression in the distribution of the glaciers, which are of great extent among the mountains on the coast, but are entirely wanting on elevations 4,000 to 5,000 feet high, situated near and even north of the Arctic circle.

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RECENT PUBLICATIONS.

American Meteorological Journal. A Monthly Review of Meteorology. July-September 1894. Vol. XI. Nos. 3-5. 8vo.

The principal articles are:—Changes in the definitions of clouds since Howard: by H. H. Clayton (14 pp.) By following the changes in cloud nomenclature since Howard, the author says that it seems clear that there has been a gradual evolution during which differences and distinctions not recognised by Howard have been established, and errors due to perspective, as in the case of the cumulo-stratus, have been corrected. Thus a distinction between high and low cirro-stratus and high and low cirro-cumulus has been established, and the lower forms called alto-stratus and alto-cumulus. The stratus has been separated into fog and low sheet clouds, and two distinct forms of rain cloud recognised.—The newspaper weather maps of the United States: by R. de C. Ward (11 pp.).—Psychrometer studies: by Prof. H. A. Hazen (4 pp.).—Frequency of amounts of precipitation: by Prof. M. W. Harrington (12 pp.).—Precipitation and temperature and their effects on crop production in Texas for the year 1893: by Dr. I. M. Cline (9 pp.).—On cloud formation: by Prof. W. von Bezold (19 pp. and 2 plates). This is a translation of an address delivered in Berlin in November 1893, and published in *Himmel und Erde*, Vol. VI. No. 5.—Summer hot winds on the great plains: by Dr. I. M. Cline (12 pp.). Apparently the conditions on which the development of hot, dry winds over the eastern slope of the Rocky Mountains and eastward depends are the presence of nearly stationary or slow moving low pressure areas along the eastern slope and then eastward, with a relatively high pressure over the Pacific off the coast of Oregon or in that vicinity. In no instances are hot winds noted with a low pressure area which moves eastward with any degree of rapidity.—The Meteorological Services of South America: by A. L. Rotch (5 pp.). This is the first of a series of papers in which the author proposes to give an account of the meteorological services in the South American States based on a personal inspection in 1893. In the present paper he deals with Peru, Chili, and the Falkland Islands. In previous numbers Mr. Rotch has given similar notices of several of the European Weather Services.

Annuaire de la Société Météorologique de France. December 1893-March 1894. 4to.

The principal articles are: Résumé des observations centralisées par le Service hydrométrique du bassin de la Seine, pendant l'année 1892: par M. Babinet (35 pp.).—Note sur l'ouragan de Maisons-Laffitte, le 21 Septembre 1893: par G. Raymond (8 pp.).—Sur les observations pluviométriques de M. le Dr. Bérigny à Versailles (Seine et Oise): par V. Raulin (3pp.).—La pluie à Aragorri: par A. Angot (3 pp.).

Journal of the Scottish Meteorological Society. Third Series. No. X. 8vo. 1894.

Contains:—The monthly and annual Rainfall of Scotland, 1866 to 1890: by Dr. Buchan (22 pp. and 13 plates). Tables and maps are given, showing the mean monthly and annual rainfall at 324 stations for the 25 years. It is pointed out that the three prominent causes which determine the amount of the rainfall are the rise and fall of the temperature with season, the prevailing winds, and the physical configuration of the country with reference to these winds.—The Climate of Braemar: by R. C. Mossman (17 pp.). This is a discussion of observations extending over a period of 38 years, 1856-1893. The station, which is 1,111 feet above sea level, was founded in 1855 by H.R.H. the late Prince Consort.—Hygrometric researches at the Ben Nevis Observatory: by A. J. Herbertson (8 pp.). These researches were undertaken with the view of determining the amount of water vapour in the air under varying conditions. The gravimetrical method was adopted

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of measuring the quantity of water vapour in the atmosphere by drawing a known volume of air through drying tubes, weighed previously to and after each experiment; and, at the same time, the ordinary dry- and wet-bulb thermometers were read at regular intervals, and also the general weather conditions noted. As regards the tabulation of dew points, vapour pressures, and relative humidities at the Ben Nevis Observatory, where the mean annual temperature is 30°·9, it seems certain that, for all temperatures about or below the mean, tables based on Regnault's formulæ give much truer values than those based on Glaisher's factors.—Comparison of observations at the low level Observatory, and at the Public School, Fort William: by R. T. Omond (6 pp.).

Meteorologische Zeitschrift. Redigirt von Dr. J. HANN und Dr. G. HELLMANN. June-September 1894. 4to.

The principal contents are:—Ueber den grossen Staubfall in Schweden und angrenzenden Ländern am 3. Mai 1892: von A. E. Nordenskiöld (18 pp.). On this day a fall of dust occurred over a narrow strip of country extending from Finland to the mouth of the Elbe. The dust was distinctly granular, and analysis showed that its main constituents were:—

	Per cent.
Silica	58
Alumina	18
Loss on Combustion (carbonaceous matter)	15
	66

Baron Nordenskiöld cites numerous other dust-falls, and gives analyses of dust collected from crevices in steeples and other rarely visited elevated localities. He concludes, as the result of the whole inquiry, that the earth is encircled by a cloud-ring composed of matter in a great measure silicious. Some of the dust-falls are distinctly volcanic, but that under consideration was not so. In the case of the Atlantic dust-falls there is a large admixture of local terrestrial dust with this cosmical dust, but in higher latitudes the cosmical dust comes down unadulterated. The phenomena of the zodiacal light are, according to the author, evidently related to the dust-ring.—Ueber die Anwendung der Photogrammeter zur Messung von Wolkenhöhen: von P. Åkerblom (6 pp.). This a description of a double camera fitted on a theodolite intended for the production of photographs of the same part of a cloud from the extremities of a base-line, with formulæ for calculation of the resulting heights and velocities. —Die Gewitter und der Wettersturz am 4. September 1892 in den Ostalpen: von K. Prohaska (11 pp.). This is an account of the most important development of thunderstorms which has been noticed in Carinthia since observations of such phenomena have been organised there in 1885. Dr. Prohaska argues for the existence of a strong inclination of the axis of a depression which accompanied the storms, and gives two isobaric charts for the same hour, one at sea level, the other at the level of 3,000 metres, the latter showing the centre of the depression shifted nearly 90 miles to the north. The discussion of the effect of this as regards descending movements in front of an advancing depression, and ascending in its rear, will well repay perusal.—Die tägliche Periode der Richtung (und Geschwindigkeit) des Windes auf dem Eiffel-Thurm: von Dr. A. Sprung (11 pp.). The author has dealt not only with the direction but also with the velocity of the wind for two full years. As regards the latter, the velocity at the base has its maximum between noon and 2 p.m. throughout the year, but on the top the minimum falls during the day hours, and its time varies through five hours, falling at 9 a.m. in summer and at 2 p.m. in winter. As regards direction there is strongly marked backing in the forenoon and veering in the afternoon. In winter the changes are not so decided, but falling in with the change in the hour of minimum velocity. Dr. Sprung concludes the paper by saying that the level of the station was still rather low, but that the results give a general support to the theory of vertical changes propounded by Espy and Köppen.—Die Resultate der meteorologischen Beobachtungen auf dem Pic du Midi: von Dr. F. Klengel (20 pp.). This paper has

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extended over three numbers of the *Zeitschrift*. The author's conclusions are: 1. The climate is about 4° warmer than the Western Alps, and about 5° warmer than the Eastern Alps at the same level. This is due to its lower latitude. 2. The annual range of temperature at the summit is very great. 3. The chief features of the Pyrenean climate are the cold spring and the great contrast between spring and autumn. 4. April is especially cold, owing to the fact that in that month the track of Atlantic depressions comes near. 5. The absolute minima appear very abnormal. The mean and absolute maxima are very high. 6. The non-periodic temperature oscillations are very great at the summit. 7. The yearly period of pressure is chiefly marked by the depression of April. 8. The diurnal amplitude of pressure appears very large in comparison with Alpine stations. 9. As to rain, a maximum at between 7,500 and 7,900 feet is clearly marked.—Prof. C. Marangoni über den Hagel (10 pp.). This communication is a translation by Dr. J. M. Pernter of papers in the *Atti della R. Acad. dei Lincei* for 1893 and 1894. The author goes back to Volta's original explanation of hail formation, and he points out that if we make allowance for Volta's ignorance of modern thermal and electrical discoveries, we must admit that he showed—1. That the cold was due to evaporation; 2. That the cause of growth of the hailstones is electrical repulsion and attraction; and 3. That electricity is not the primary cause of the hail, but its result and a secondary cause. The other papers deal with the shapes of the hailstones, the repulsion of the stones in the cloud, and the peculiar noise of hail showers.—Beiträge zur Theorie des Ventilations-Pyschrometers: von W. A. Nippoldt (17 pp.). This is an elaborate discussion of the principle on which the Hygrometrical Tables in general use are based, especially with reference to the recent proposals of Dr. Ekholm as regards the formula for hygrometrical reductions below the freezing point. The author discusses the works of Chistoni, Pernter, Sworykin and others on the same subject, and the paper well merits study from those interested in the question.—Die Anticyklonen des Winters 1893-94, nach Beobachtungen auf dem Brockengipfel (1142 m.): von R. Süring (8 pp.). The author remained on the top of the Brocken for some months, in order to ascertain the advisability of erecting an observatory there. The paper gives an account of his results during the anticyclone of that winter, and he comes to the conclusion that the frequent rises of temperature which are observed are due mainly to the descending currents of air, and so probably to a sort of *föhn* action.

Proceedings of the Royal Society. Vol. LVI. No. 336. 8vo. 1894.

On the electrification of air: by Lord Kelvin and M. Maclean (10 pp.). The authors describe some experiments which they made to find if a small unchanged portion of air could be electrified sufficiently to show its electrification by ordinary tests, and could keep its electrification for any considerable time; and to test whether or not dust in the air is essential to whatever of electrification might be observed in such circumstances, or is much concerned in it. From the experiments it is seen that, on the supposition of electric density uniform throughout the spherical enclosure, each cubic centimetre of air experiences an electrostatic force towards the boundary in simple proportion to distance from the centre, and amounting at the boundary to nearly 10 per cent. of the force of gravity upon it; and electric forces of not very dissimilar magnitudes must have acted on the air electrified as it actually was in the non-spherical enclosure used in the experiments. If natural air or cloud, close to the ground or in the lower regions of the earth's atmosphere, is ever, as in all probability it often is, electrified to as great a degree of electric density as the authors have found it within their experimental vat, the natural electrostatic force in the atmosphere, due, as it is, no doubt, to positive electricity in very high regions, must exercise an important ponderomotive force quite comparable in magnitude with that due to difference of temperatures in different positions. It is interesting to remark that negatively electrified air over negatively electrified ground, and with non-electrified air above it in an absolute calm would be in unstable equilibrium; and the negatively electrified air would therefore rise, probably in large masses, through the non-electrified air up to the higher regions, where the positive electrification is supposed to reside. Even with no stronger electrification than that which

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the authors have had within their experimental vat, the moving forces would be sufficient to produce instability comparable with that of air warmed by the ground and rising through colder air above. During a thunderstorm the electrification of air, or of air and the watery spherules constituting cloud, need not be enormously stronger than that found in the experiments. This is seen by considering that if a uniformly electrified globe of a metre diameter produces a difference of potential of 38 volts between its surface and centre, a globe of a kilometre diameter, electrified to the same electric density, reckoned according to the total electricity in any small volume (electricity of air and of spherules of water, if there are any in it), would produce a difference of potential of 38 million volts between its surface and centre. In a thunderstorm, flashes of lightning show us differences of potentials of millions of volts, but not perhaps of many times 38 million volts between places of the atmosphere distant from one another by half a kilometre.—On rapid variations of atmospheric temperature, especially during Föhn, and the methods of observing them: by J. Y. Buchanan, F.R.S. (20 pp.). It has not been before remarked that the true Föhn occurs in our own country, and with its characteristics quite as well marked as in Switzerland. It is sometimes supposed that a great absolute height of mountain chain is required for its production; but this is not so. A relative height of 3,300 to 3,950 feet is quite sufficient for its production; and this is equally available on the west coast of Scotland and on the northern slopes of the Alps. The author describes some observations which he made in the summer of 1893, which was abnormally warm all over the north of Europe. In the beginning of July he observed the Föhn at Fort William, and in the latter part of August in the Upper Engadin, and more particularly in the valley occupied by the Morteratsch glacier. Besides the observation of the varying temperature of the air itself, the investigation of the temperature gradient set up between the melting ice surface of the glacier and the hot winds blowing over it presented considerable interest. The curious fact was observed that while the hot wind was blowing over the glacier and melting the surface in abundance, the temperature of the air, as close to the ice as a thermometer could be applied without touching the ice, was never lower than 41°·9.

Sitzungsberichte der kaiserlichen Akademie der Wissenschaften in Wien. Mathem.-naturw. classe: Band CIII. Abth. II. January 1894. 8vo.

Contains: Beiträge zum täglichen Gange der meteorologische Elemente in den höheren Luftschichten: von J. Hann (48 pp.). This is a discussion of the results of two different mountain stations, Ontake (10,023 feet) in Japan and Mont Blanc (15,878 feet), M. Vallot's observations. The observations of pressure and temperature are discussed with great care, and from almost every point of view that is possible, and each result is compared with those given by Dr. Hann in his previous communications on similar subjects. The final outcome is thus stated: "The results of the pressure observations at the summit of Mont Blanc are in complete accordance with those at other summit stations, and also on the Eiffel Tower, and they all indicate that in the upper strata of the free atmosphere the daily range of temperature is much less than what is shown by direct temperature observations."

Symons's Monthly Meteorological Magazine. July-September 1894. Vol. XXIX. Nos. 342-344. 8vo.

Contains: The May frost of 1894 (7 pp.).—Sun spots and air temperature (1 p.).—The Antwerp Congress (1 p.).—Rainfall and flood at Bristol (2 pp.). This occurred on July 24th, when 2·53 ins. of rain fell in ten hours and a half. —Heavy rain and hailstorms, July 1894 (2 pp.).—Rain of July 1894 in the South-east of England (1 p.). The total for the month was considerably more than twice the average.—The British Association at Oxford (11 pp.). This gives notes of some of the meteorological papers read in the various sections.

Transactions of the South African Philosophical Society. Vol. V. Part II. 1886-1889. 8vo. 1893.

Contains: The winter storms of South Africa, illustrating the value of Cape

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Point as a warning station: by A. G. Howard (16 pp. and plate). Cape Point is a peak standing up about 816 feet above sea level, and in the author's opinion offers itself as an indicator of coming storms to those who will take the trouble to investigate what its warnings portend.—The Storms of South Africa: by A. G. Howard (12 pp.).—The barometer: its reduction to sea-level: by A. G. Howard (7 pp.).—On some photographs of lightning flashes: by C. R. Woods (6 pp.).—Sea-levels in South Africa from barometric observations: by F. Guthrie (8 pp.).—The relation of the sand dune formation on the South-West Coast of Africa to the local wind changes: by H. C. Wilmer (4 pp.).

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THE END.

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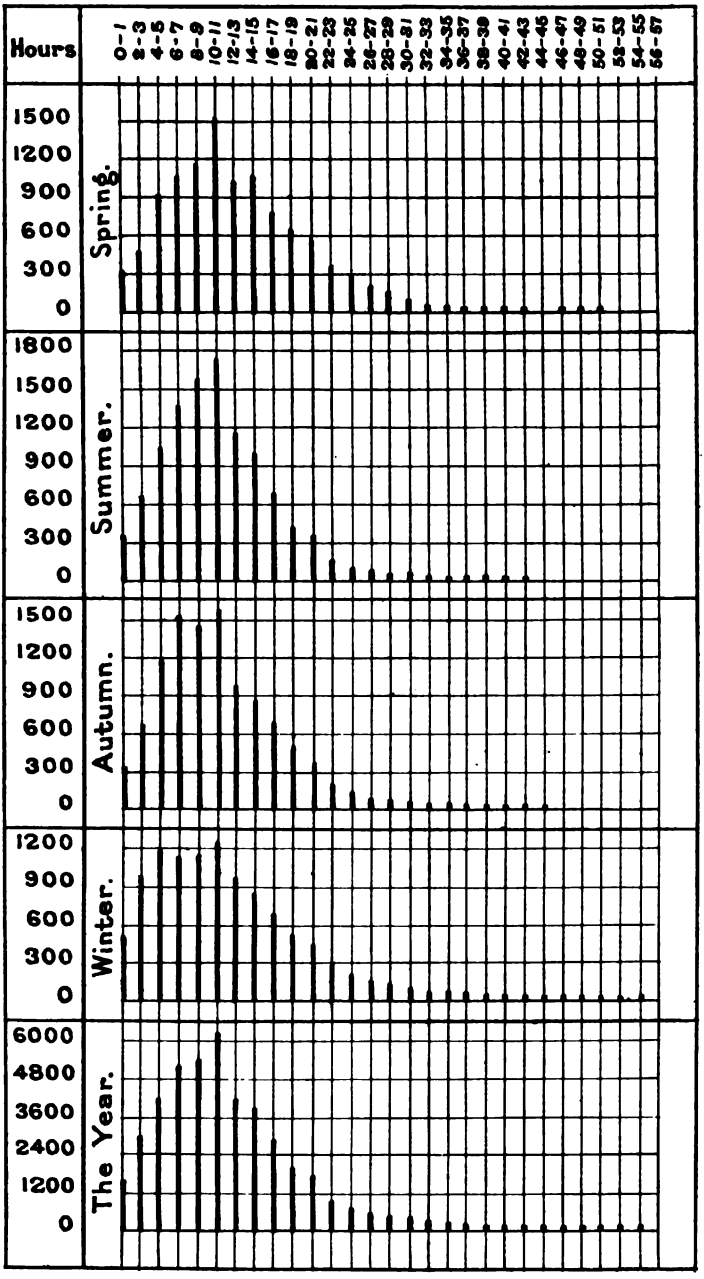
NUMBER OF HOURS DURING WHICH DIFFERENT HOURLY VELOCITIES OF WIND WERE REGISTERED AT THE ROYAL OBSERVATORY, GREENWICH. 1888 TO 1892.



The contraction of the scale for the year enables the yearly indication to be more readily compared with those for the quarters.

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SOME CHARACTERISTIC FEATURES OF GALES AND STRONG WINDS.

Fig. 1. Nov. 15, 1893.

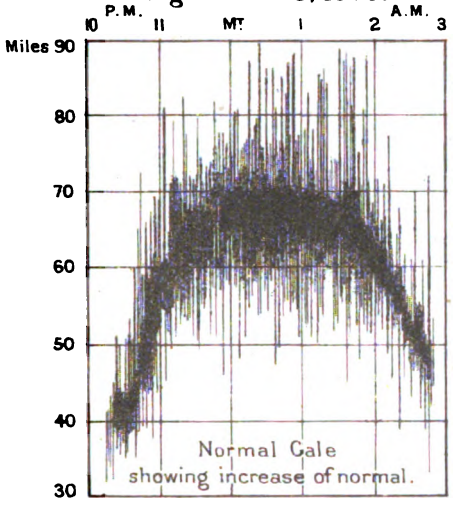


Fig. 2. Jan. 7, 1893.

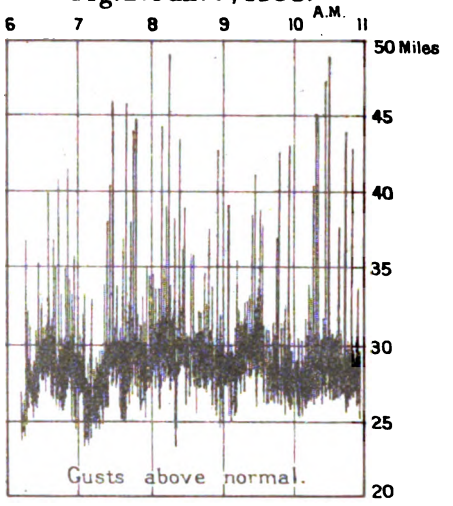


Fig. 3, Feb. 3, 1889.

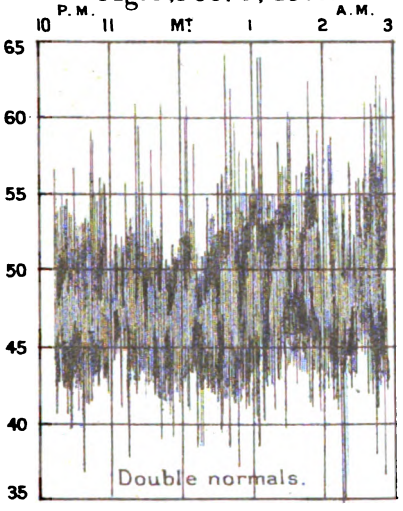


Fig. 4, Dec. 10, 1891.

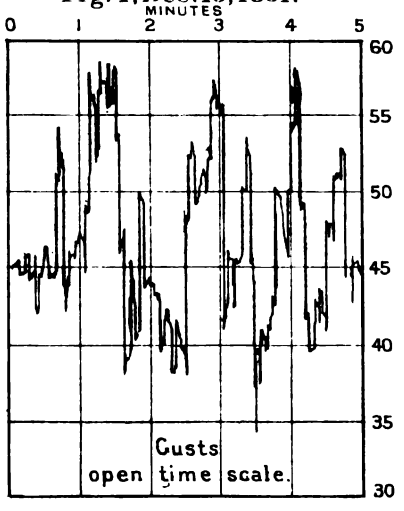


Fig. 5. Oct. 16, 1890.

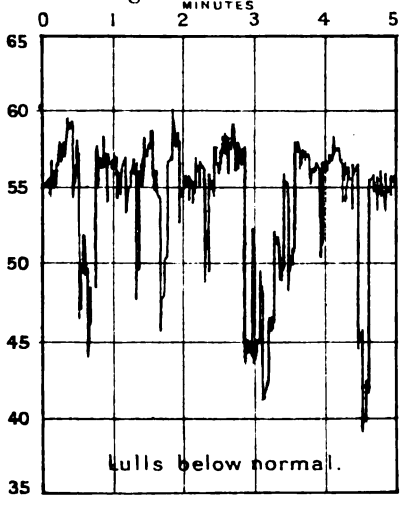
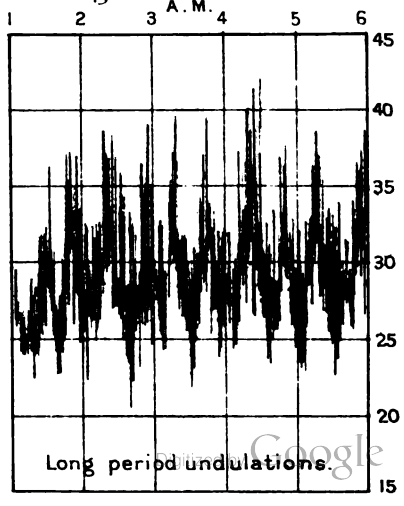


Fig. 6. Jan. 14, 1891.



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ERRATA.

Page 40, line 18, *for* December 20th *read* December 19th.

Page 154, line 20, *for* Kenilworth, 2 ft. 3 in. *read* 2 ft. 6 in.

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OF THE

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VOL. XXI. JANUARY 1895. No. 98.

Suggestions as to the Methods of determining the Influence of Springs on the Temperature of a River, as illustrated by the Thames and its Tributaries.

BY H. B. GUPPY, M.B.

(Communicated by F. C. BAYARD, LL.M., F.R.Met.Soc.)

[Received November 1st.—Read November 21st, 1894.]

SOME of the small tributaries of the Thames, like the Malden River[1] and the Wandle, which are mainly fed by head-springs appearing at the surface, afford convenient opportunities for observing the influence of springs on river temperature. In suggesting the following methods of investigation, I would remark that our acquaintance with the thermal economy of rivers, though much increased by Dr. Förster's recent admirable memoir,[2] is not yet sufficiently exact to enable us to assign its true value to each of the lines of inquiry indicated below. Other better plans will doubtless present them-

[1] Also known as the Ewell River and the Hogsmill.

[2] "Die Temperatur fliessender Gewässer Mitteleuropas" (*Geographische Abhandlungen*. Wien: band V., heft 4, 1894).

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selves to the minds of some, and it is probable that novel means will be disclosed in the course of each investigation.

(A.) *By a comparison of the curves of the monthly means of the temperatures of the air and of the water for the river under observation with those of a river beyond the controlling influence of springs.*

I assume for the rivers of this country, that is to say for rivers very small in size when compared with many continental rivers, that the limits of the control of the springs are passed when the curve of the water temperature is above that of the air all through the year, the difference being greatest in summer, when it varies usually between 2° and 4; and least in winter, when the curves are only 1° or so apart. This is true not only for the Thames at Greenwich within tidal influence,[1] but it also applies to the same river at Kingston beyond the reach of the tides;[2] and it is true as well for the more important of its tributaries at their mouths, if the Cherwell at Oxford is a typical instance.[3] It is the general character of the "Flachlandflüsse" of Dr. Förster, rivers of this class being defined by him as warmer than the air all through the year.

When, therefore, in the case of any of the Thames tributaries we find a marked departure from this rule, we must look for the disturbing cause; and if, as will generally happen, we can exclude those connected with a mountain course or an origin in a lake or a temporary disappearance under ground, we must look to the springs for an explanation. Thus by comparing the accompanying charts of the curves of the air and water temperatures for the Cherwell at Oxford and the Kennet at Marlborough, both of them tributaries of the Thames, we perceive that the Cherwell at its mouth has the thermal regime of a river of the type above referred to, whilst the Kennet 10 miles from its source exhibits curves of a different type. The Cherwell is warmer than the air throughout the year, a character that would have been more strikingly illustrated in the diagram if the observations had been made during the hour preceding noon, the time of mean temperature. On the other hand, the Kennet, during the summer half of the year, is a great deal cooler than the air. The Kennet at Marlborough is in fact an example of the "Quellflüsse" of Dr. Förster, or, in other words, it is largely controlled by the springs. It finds its representative in a tributary of the Danube, the Ach, at Memmingen, the data for which, together with a chart of the curves, are to be found in Dr. Förster's monograph.

(B.) *By a comparison of the range of the monthly means*[4] *of the tempera-*

[1] Sir G. B. Airy in *Proc. Roy. Soc.* Lond. Vol. 34. These well-known observations covered a period of 33 years.

[2] From the writer's unpublished observations, which were continued for two years.

[3] Mr. Chapman's series of ten years' observations, on the Cherwell, *Brit. Ass. Rep.* 1891.

[4] The range of the monthly means during a series of years is not the difference between the months with the highest and lowest averages; but it is greater than this, as the hottest and coldest months vary considerably. It is estimated from the aggregate of all the ranges. Calculated thus, it is 28°·9 instead of 26°·3 for the Thames at Greenwich (33 years), and 28°·8 instead of 26°·8 for the Cherwell at Oxford (10 years).

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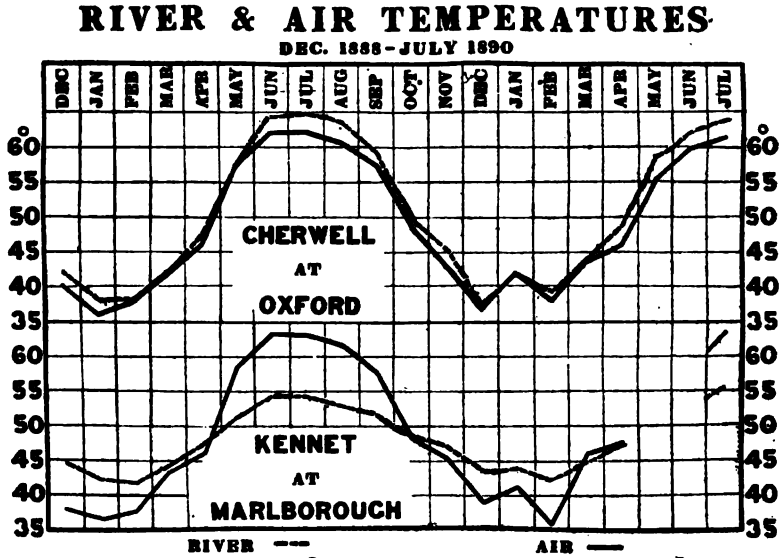
ture of the river under investigation with that of a river beyond the control of the springs.

This method is founded on the principle that the range would be very small at the sources, and would increase with distance from the springs as far as the limit of their influence. At the sources the range would be probably 5° or 6°. When the river reaches that part of its course where it passes from under the control of its springs and becomes subject to the agencies affecting atmospheric temperature, the range of the monthly means in this



country would be between 25° and 30°. The Thames and its tributaries are well fitted for the application of this method. Mr. Bayard's observations on the Wandle springs[1] enable us to place the range of this small river at its sources at about 6°,[2] whilst the Cherwell at Oxford ranges about 29°, the Thames at Kingston about 30°, and at Greenwich about 29°.[3] These data approximately determine the limits of the possible range of water temperature for the Thames and its tributaries. When, therefore, as in the case of

[1] Some of the observations were made on springs at their exits, and others on spring-fed pools, so that the results are of a varied character, the ranges of the monthly means differing greatly, the smallest being under 1° and the largest as much as 17°.

[2] The range of the combined monthly means of the ten springs observed by Mr. Bayard during the year commencing with November 1888 is 47°·6 – 53°·7. This gentleman tells me that on any given day the mean of the ten springs was very near the temperature of the Wandle at its commencement. His observations, which extended over 15 months, are referred to in Dr. Mill's *British Association Report*, 1891. They are given in full by Mr. Cushing in *Proc. Croydon Na'. Hist. Club* for 1891.

[3] It should be noted that the observations at Oxford, Kingston, and Greenwich cover periods widely different in extent (*vide supra*).

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the Kennet at Marlborough,[1] 10 miles from its sources, we find a tributary with a range of only about 12°, we may, if other influences are excluded, attribute this result to the springs.

Now the Kennet runs a course of about 50 statute miles before it joins the Thames; and the question to be answered is, how far down the stream are its waters under the controlling influence of the springs. We have seen that spring influence is predominant 10 miles from the sources; but since the Cherwell is not under the control of the springs at its junction with the Thames after a course of nearly 40 miles, we may infer that the Kennet, long before it joins the Thames at Reading, will be, like the Cherwell at Oxford, freed from their sway. We can therefore surmise that a tributary of the Thames 40 to 50 miles in length throws off the equalising influence of the springs before it joins the main stream. I will subsequently show that smaller tributaries, like the Malden River and the Wandle, which are respectively six and nine miles in length, and are chiefly fed by head-springs, are under the control of the springs for the whole of their courses.

Beverley Brook, another affluent of the Thames, about nine miles in length, is far less under the influence of head-springs than the two rivers just mentioned. In its upper course it becomes very low in summer; and in fact when it reaches the outskirts of Wimbledon Common, about five miles from its mouth, its temperature is regulated by the atmospheric agencies, so that, judging from a few observations which I have made, the range of its monthly means would there be quite 30°. As it flows past the Common and through Kingston Vale it receives a considerable accession of water from perennial rills and subsoil oozings, so that its temperature becomes there very irregular. But their effect is evanescent; and probably enough, in summer, its temperature at the mouth will be as high as, or higher than, the temperature of the Thames.

The Mole, a Thames tributary, about 25 miles in length, would appear, from some observations which I have made in different seasons of the year, to exhibit a range of monthly mean temperatures 2° or 3° less than that of the main river. The principal difference occurs in summer, when, near its mouth, it is usually 2° or 3° cooler than the Thames. Now it is at this season in particular that the Mole pursues a subterranean course for a mile or two under Box Hill,[2] some 17 miles along its banks from the mouth; and it is to this circumstance rather than to the effect of the head-springs that it owes its comparative coolness on nearing the Thames.

[1] The range of the monthly means of the Kennet at Marlborough in 1889 was 41°·8 (February) to 54°·3 (June), or 12°·5. The Cherwell at Oxford in the same year had a range of 27°·4, the difference between 37°·3 in December and 64°·7 in July. The observations for both rivers were made at 9 a.m. Those for the Kennet were undertaken by Messrs. W. and H. Maurice, and the results are given in Dr. Mill's *British Association Report*, 1891. Other rivers dealt with in this report, such as the Stour at Canterbury, afford evidence of spring control in the limited range of the monthly means.

[2] It would be of interest to determine the difference between the temperature of the river as it disappears in the "swallows" and its temperature when it reappears.

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Looking at these data relating to six Thames tributaries, the Cherwell, the Kennet, the Mole, the Malden River, Beverley Brook, and the Wandle, I should consider that affluents mainly fed by head-springs and up to 10 miles in length never get beyond the control of the temperature of the springs; that those 25 miles long are able to free themselves from their sway; and that rivers 40 to 50 miles in length are not affected by the springs beyond the upper half of their course.

The range of the monthly means for any of our rivers may be readily obtained[1] by taking observations every other day in December, January, and February, and in June, July, and August, at 11 a.m. in summer and at noon in winter.

(C.) *By a comparison of the range of the monthly means of the river temperature with that of the air in the shade.*

A river of the flat country in England, when free from disturbing influences, will be near the temperature of the air in winter, but in summer it will be usually from 2° to 4° warmer than the air, so that the range of the monthly means for the river will be rather greater than that for the air. Therefore, when we find the water-range markedly less, we must look out for the disturbing cause; and if we are able to exclude those arising from a mountain or a subterranean course or from an origin in a lake, we are at liberty to consider such an effect to be due to the controlling influence of springs. This method is, of course, included in that relating to the comparisons of the curves of the air and water temperatures, the method A of this paper; but I have given it a separate place because observations need only be taken in the winter and summer months named under method B. As it has been already illustrated, I shall merely give emphasis to its utility by directing attention to the diagrams for the Cherwell and the Kennet.

(D.) *By comparing the daily range of water temperature at different stations along a river's course.*

This would be almost nothing at the springs, and would gradually increase with distance run until the limit of spring influence is passed, when it would become more or less stable. Such is the behaviour of spring-brooks and perennial rills,[2] and we cannot doubt also of several of the tributaries of the Thames. This method to be persistently carried out would involve considerable trouble; but employed in a limited fashion, it would be a valuable preliminary test. Only four or five sets of observations would then be required, and in rivers where springs control the temperature for several miles, the stations should be a mile or so apart; but in streams or small rivers, where the observer can within an hour-and-a-half visit all the stations, one person can efficiently carry out the scheme, since in that interval the water temperature would but slightly change. Fine weather should be selected, and each set of observations ought to consist of three in the 24 hours, namely, during

[1] This subject is dealt with by the author in *Proc. Roy. Phys. Soc. Edin.* January 1894.

[2] I have discussed this matter in *Science Gossip* for October 1894.

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the hour following sunrise, between 8 and 4 p.m., and at the following sunrise; or the series could begin in the afternoon. The corresponding minimum and maximum temperatures of the air in the shade should be at the same time noted; but, in the absence of self-recording instruments, observations with an ordinary thermometer at sunrise and at 2 p.m. would give approximate results.

I may remark that this method is by no means the simple plan it at first appears to be. Hot days and cool nights, with the consequent great diurnal range of air temperature, afford the best conditions, and the temperature of the river at its sources should be about that of the daily mean of the air. For instance, with the air ranging between 40° and 65° and the river at its sources about 52°; circumstances we might expect to find early in May or early in October; we ought to get good results. In the middle of summer, when the air minimum and the temperature of the springs would be near together, the observations would have to be restricted to the determination of one of the elements of the daily range, namely the rise.[1]

(E.) *By a comparison of sunrise observations made at different stations along the river's course.*

In settled weather during the warm half of the year an ordinary river uncontrolled by springs is at sunrise several degrees warmer than the air. This is a well-known feature of river temperature, to which I have referred in the paper before quoted. For instance, in the case of the Thames at Kingston, I have found the difference to be frequently over 10°. At this hour, however, the temperature of a river under the influence of springs would be much nearer the air minimum and might even be lower. In winter the effect of springs would be to increase greatly the usual excess of the temperature of the river over that of the air. Four or five sets of observations, a week or so apart, would answer every purpose of a preliminary test; and in rivers where springs extend their influence for several miles, simultaneous observations should be made by different observers a mile or two apart; but in ordinary streams one observer could do it all in an hour's walk from the springs.

(F.) *By a comparison of observations made at different stations along the river's course at the hour of maximum temperature, 2 p.m. in winter and between 3 and 4 p.m. in summer.*

This method should be carried out in the manner just mentioned under method (E), namely, by simultaneous observations at stations a mile or so apart for rivers like the Kennet or the Wandle, or by a single observer in the case of brooks or streams. A hot summer afternoon and a frosty day in winter should be chosen for the purpose, the seasons of spring and autumn

[1] The daily range of river temperature and the time of observation are discussed in my paper in *Proc. Roy. Phys. Soc. Edin*, Jan. 1894. The matter is ably handled by Dr. Förster in *Geograph. Abhandl.*, Wien, band V. heft 4, 1894. The mean daily range of the Thames at Greenwich is 2°·1, and at Kingston about 1°·5. In tributaries of the Thames beyond the control of the springs it would be probably not under 4° for the year's average, and as much as 6° in July, and as little as 3° in winter.

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being less suitable, since at those periods the temperatures of a river within and beyond the control of the springs are not far removed. It is scarcely necessary to point out that in winter the river temperature would fall with distance from the springs; whilst in summer it would increase, the change proceeding in either case until a constant temperature betokens the limit of their influence.

(G.) *By the comparison of the results obtained from a single series of observations made in one day along the whole course of a small tributary like the Wandle, or along the upper course of a larger tributary as the Kennet.*

This plan, which can be accomplished in a day's walk, is a rough and ready method that might be useful in first examining a river with a view to a more systematic inquiry. The seasons when the constant temperature of the river beyond the control of the springs is farthest apart from the temperature of the sources, namely in the middle of winter and the middle of summer, should be selected; and the main stream, in this case the Thames, will afford a valuable means of comparison. I have put this method into practice in the instances of the Wandle and the Malden River, the results being given in Tables I. and II. For the observations on the Wandle springs I am entirely indebted to the courtesy of Mr. Bayard, who took me to the various localities.

With regard to the Wandle series, the coolness of the river, relatively to the Thames, along the whole of its course is apparent. The fall of temperature in the middle third of the series is due probably to those observations being made in the forenoon, while those of the upper third were made in the afternoon. The rise of the temperature near the mouth is doubtless the effect of the accumulation of the water above the dam, whereby an element of pond *régime* is introduced, namely a higher plane of temperature. The low atmospheric temperature of the previous night introduced another disturbing cause, as it would affect the Wandle more than the Thames; but judging from my observations on the diurnal range of the Mole and the Malden River, this would not account for more than 2° of the difference. After allowing, however, for a rise in the temperature of the Wandle as the day progressed, and for a slight increase in that of the Thames, I arrive at the conclusion that the Wandle during the afternoon would not have had a higher temperature than 56° in any part of its course, whilst the Thames temperature would have been about 61°. By stating it in this way the disturbing causes are eliminated to a great extent, since the elevation of temperature due to the dam at the mouth is no doubt counterbalanced by the greater nocturnal cooling of the Wandle as compared with the Thames. The most satisfactory plan of carrying out this series of observations in summer would be to leave Hackbridge at 1 p.m., arriving at the Thames not later than 6 p.m. By this means we should be able to disregard the uncertain element of the daily rise of temperature. We should be observing the Wandle during the heat of the afternoon, and the Thames on our arrival would be still at its maximum. In winter the method would have to be adapted to the shortness of the day; but the daily rise of river temperature would on a cold frosty day be almost absent.

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TABLE I.—Temperature of the Wandle River on September 4th, 1894.

Average rate of current 1 foot per second. Usual depth 2 to 3 feet. Average width 50 or 60 feet. Weather fairly sunny to 2 p.m. Air in the shade at Kingston 41°–61°. The Wandle proper begins a few hundred yards above Hackbridge at the junction of the Croydon and Carshalton branches.

Time.	River.	Locality.	Distance from Mouth.	Temperature.
			Miles.	°
7.15 a.m.	Thames	Kingston (above tidal influence)	..	59·4
8.30 ,,	Thames	Wandsworth Pier (tide ebbing)	..	60·6
9.0 ,,	Wandle	Dam close to mouth	¼	54·8
9.15 ,,	,,	High Street, Wandsworth	½	54·4
9.45 ,,	,,	Duntshill, below railway	1¼	52·8
10.15 ,,	,,	Plough Lane, Garratt	2¼	52·8
11.0 ,,	,,	Merton Abbey	3¼	52·7
11.15 ,,	,,	About 500 yards above Merton Abbey, by roadside	4	52·7
12.30 p.m.	,,	Bridge, Mitcham, to Sutton Road, near Ravensbury Park	5½	53·7
1.0 ,,	,,	Beddington Corner	6½	54·0
1.45 ,,	,,	Hackbridge, 300 yards below junction of the two head branches	7	53·5
2.0 ,,	Carshalton Branch of the Wandle	About 300 yards above junction, below railway	7⅛	54·9
2.45 ,,	Croydon Branch of the Wandle	About a third of a mile above junction	7½	54·0
4.0–4.30	Springs of the Carshalton Branch of the Wandle	Park Wall, Phillpott's Corner	..	58·0
		Park Wall, Haydon's Corner	..	55·8
		Lower Pond Steps	8 to 8½	51·1
		Waterhouse Pool	..	50·8
		Upper Pond, C. House Stream	..	52·2
4.45–5.15	Springs of the Croydon Branch of the Wandle	Wallington Corner	..	52·6
		Smee's Mill I.	..	54·8
		Smee's Mill II.	8 to 9	52·2
		Ellis Road Stream	..	53·4
		Ellis Stream	..	51·8

Note.—The mean of the temperature of the springs is 53°·3. In several cases the temperature is not that of the spring at its exit, but of the spring water issuing from a pool. Although the initial temperature of the Wandle is considerably affected by the artificial pools and ponds at the sources, it is probable that without man's aid this river would mainly rise from spring-fed pools.

Whilst the Wandle is fed by its head-springs, and does not increase much in bulk on its way to the Thames, the Malden River, which is scarcely half its size, is joined by three lesser tributaries in its course, and gains considerably in dimensions as it approaches the Thames. For these reasons the Wandle is far better suited for this investigation. My observations on the Malden River were confined to the main stream, and to one of the principal sources in the midst of the village of Ewell. Of the temperatures of the tributaries I learned nothing, except in so far as they found expression in that of the main stream. The series, however, plainly shows that the Malden River is able to carry the cool waters of its springs into the Thames. It rarely does so, however, to any considerable extent, since by the intervention of a mill it expands into a deep pool at its mouth, the surface waters of which are readily heated. The Malden River is in fact a

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TABLE II.—Temperature of the Malden River (also known as the Ewell River and the Hogsmill), on August 30th, 1894.

Average rate of current 1 foot in two seconds. Usual depth 1 to 2 feet. Average width 20 feet. Hot sunny weather. Air in the shade 51°—73°.

Time.	River.	Locality.	Distance from Mouth.	Temperature.
			Miles.	°
2.15 p.m.	Ewell Springs	Ewell village	6	51·5
	,, ,,	Exit from first pool	5⅞	53·5
	,, ,,	Exit from second pool	5⅝	57·5
3.0 ,,	Malden River	Railway arch	5½	58·0
3.45 ,,	,, ,,	Roxley Farm	4⅛	58·5
4.45 ,,	,, ,,	Surbiton to Ewell road	3¼	59·0
4.15 ,,	,, ,,	Malden Church	3	59·3
5.30 ,,	,, ,,	Quarter mile above South-Western Railway	1¼	59·8
6.0 ,,	,, ,,	Oil Mill Lane, Kingston	¼	60·6
6.15 ,,	Thames	Kingston	..	64·6

much afflicted stream in this respect, even more so than the Wandle. It is to be noted in my observations that the water gained 6° in temperature by passing through the broad shallow pools in connection with the mills in the village of Ewell. If allowed to run free from its springs to the Thames, this tributary would doubtless reach that river 8°, instead of, as on this occasion, 4° cooler than the Thames. I have already remarked that the temperature of the head waters of the Wandle is influenced by ponds at the sources.

(H.) *By determining the distance from its sources at which the river begins to freeze.*

Here observation can be supplemented by the experience of residents and from the local histories. The old county histories, whilst noting the inability of the Wandle to freeze in the upper part of its course, attribute it to the influence of the mills. Though the mills can afford no explanation, their records may be worth while examining. I have been informed that the Malden River, which is stated never to freeze at Roxley Farm a mile-and-a-half from its sources, rarely freezes at Malden, a mile-and-a-half lower down, and then only at the edges.

I will conclude this paper with some remarks on the thermometer used and on the mode of investigation. The instrument I employed was a bath thermometer of the Admiralty pattern, such as is used on board Her Majesty's ships for sea temperatures. It was supplied to me by Messrs. Negretti and Zambra, accompanied by a Kew certificate, and is graduated to degrees on the stem. Not every bath thermometer will stand the test of an ordinary sunrise observation of the temperature of a river. Here the instrument has often to be pulled up 6 or 8 feet through air 10° or 12° cooler than the water, with perhaps a fresh breeze blowing. To get a correct result under such circumstances, the bulb must be relatively small and deeply set

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and the pocket capacious; and before finally selecting a thermometer it should be put to this test by an experiment at home, instruments with large bulbs and small shallow pockets are liable to fail.

It will be best, as far as possible, to make all the observations in mid-stream, and at a depth of from 18 inches to 2 feet, though, as a matter of fact, these precautions are really necessary only in the case of very sluggish rivers. It has been established by Dr. Förster and the present writer that rivers running free, with a current, say of a mile an hour, exhibit nearly the same temperature in depth and breadth. The matter is more often one of access and convenience; and for our own rivers, usually, it should be remarked, of a very sluggish type, marginal observations are only reliable when the water is moving well with the current. Slack waters in shallow places heat up rapidly, and back-waters, except where the depth is considerable, should be avoided. In case of doubt, an observer could, on a hot summer day, readily find a suitable observing station by the aid of his thermometer. The time of immersion, which varies for each instrument, should be ascertained by experiment, some thermometers requiring as much as five minutes, others as little as two or three minutes. For determining the daily range the employment of continuously immersed maximum and minimum thermometers would, in a river like the Wandle, be impracticable, except in private waters. My experience of them has been very slight.

DISCUSSION.

THE PRESIDENT (Mr. R. INWARDS) said that this paper was rather one of suggestions for future observations than a statement of results of any investigation already completed. He thought that exceptional facilities for making observations of river temperatures with respect to springs were afforded after a long drought, as then the flow would almost entirely consist of spring water. The temperatures could be corrected by comparison with those of pond water in the vicinity.

Dr. R. BARNES pointed out that the author had omitted to state at what depth below the surface of the water the temperatures were observed, as on a hot summer day the surface temperature of a stream was commonly higher than that at a depth of 3 or 4 feet. Rain, especially heavy rain, exercised an influence upon the temperature of streams by causing a layer of warmer water to accumulate on the surface. The influence of snow must also be noted. It was important, too, that the depth of the water should be noted, shallow streams being subject to greater fluctuations of temperature than those in which the water was deep.

Mr. G. CHATTERTON thought that the temperatures given in Table I. were of very little value, as considerable quantities of purified sewage from Wimbledon and Croydon were discharged daily into the river Wandle, and this sewage being at a much higher temperature than the river water, would quite mask the real temperature of the natural river.

Mr. R. W. P. BIRCH said that the paper put forward so many views that it required careful perusal before discussion, but he thought all that could be said at present concerning the temperature of rivers was that it was most equable near the springs which form them.

Mr. W. B. TRIPP remarked that it would be interesting if observations of the temperature of the dew point were taken in connection with the surface temperature of rivers. He had noticed in hot climates that the temperature of the water was at times below the dew point temperature.

Mr. H. SOUTHALL said that exposed rocks in a shallow stream considerably influenced the temperature of the water, as in hot weather the rocks became greatly heated. The River Wye, owing to the influence of rocks, rose to a very

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high temperature in hot weather, and he had known the water to reach a temperature of 81°. It appeared desirable to know the character of a river as regarded its surroundings when considering the temperature of its waters.

NOTE ON SOME EFFECTS OF THE GALE IN THE HIGHLANDS OF SCOTLAND ON NOVEMBER 17th AND 18th, 1893.

By ERIC STUART BRUCE, M.A., F.R.Met.Soc.

[Received October 4th.—Read November 21st, 1894.]

While spending my summer holidays in Perthshire, I had occasion to witness the disastrous effects of the great gale of November 1893 upon the trees in some parts of that county. The storm has been fully chronicled in the paper read before the Society by Mr. C. Harding on December 20th, 1893.[1] It may, however, be of interest to show some photographs descriptive of the destruction of trees in Perthshire, especially in the valley of the Tummel, where I believe the storm wreaked its greatest violence. I am enabled to show these photographs by the kindness of some of the landed proprietors in the district affected, who gave me facilities for obtaining them. Most of the ravages depicted in the photographs were done on the night of November 17th and early morning of the 18th. [These photographs were shown to the Meeting, but are not reproduced here.]

There could be no better example of the violence of the gale than the immediate surroundings of Lude House, Blair Athole, the residence of Mr. W. McInroy, once situated in picturesque woods, but now amidst a scene of desolation. It is no exaggeration to say that there is not a single tree in the picture that is whole. Passing to another part of the same property, the trunk shown in the photograph has been peculiarly doubled up by the wind. Some one has well described the gale as having blown the trees to pieces, and this is a very true description of its effects on several trees which I have seen, whose trunks are split and shivered as if a charge of dynamite had been exploded in their midst.

Dr. Rankin, in his letter to the *Scotsman*,[2] describes a curious incident illustrative of the force of the wind. "A slate was carried 80 yards from the roof of a joiner's house with such violence that it cut through the stem of a young fir tree and fell at the foot of it."

The view also shows the partly demolished roof of the shed. Other photographs, also on the same estate, represent the downfall and wreckage of several fine trees.

[1] *Quarterly Journal*, Vol. XX., p. 43.

[2] *Scotsman*, Nov. 22nd and 25th, 1893.

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The beautiful grounds of the Athole Hydropathic Establishment at Pitlochry suffered much from the gale. By the kindness of Mr. Macdonald, the proprietor, I can show some photographs taken the morning after the damage was done. 1. The lawn tennis ground, showing how the tree with the lawn tennis notice attached to it carried the circular seat with it. 2. A whole row of fir trees fallen along the side of a path. 3. The downfall of another tree with its circular seat. 4. Large fallen tree. 5. Mass of tree debris. 6. The effects of the gale looking towards the steps on the path from the hydropathic establishment.

Many of the trees blown down were found lying in different directions, thus pointing out that the direction of the wind changed during the violence of the storm. Messrs. Omond and Rankin have kindly supplied me with the observations at the Ben Nevis observatory as to direction, force, and velocity of the wind from 6 p.m. on November 17th to 6 p.m. on the 18th. Though the observatory is not very near the district depicted in the photographs, and the observations are taken at a considerable elevation, it may be of interest to refer to them.

The figures indicate that the direction of the wind was very variable during the early morning hours of November 18th. At 1 a.m. it was North-east ; at 2 a.m. North ; at 3 a.m. variable ; at 4 a.m. variable ; at 5 a.m. East-south-east ; and at 6 a.m. North-east again. So it is not a matter of surprise that trees were found lying in different directions in several parts of the highlands. It is possible that in some cases the varying directions may have been due to the "rebounding" of the wind from hill-sides, as suggested by Dr. Rankin in his letter referred to above. A change of direction was also noticed in the woods of Drumlanrig after the gale of January 26th, 1884. The Ben Nevis observations also show the squally nature of the gale making it impossible to assign any one value to the force. For instance, the velocity in miles per hour for 9 p.m. November 17th is put down as 31 to 85 ; for 10 p.m., 39 to 85 ; 11 p.m., 21 to 73 ; for midnight, 21 to 85.

It is highly creditable to the enterprise and skill of Mr. Macdonald that some 800 of the trees blown down on his property have been replanted, and, being temporarily supported by galvanised wire, are now thriving. It is a pity that a similar course of action was not taken by some of the other landed proprietors, especially in such spots as the pass of Killicrankie. It is no exaggeration to say that during the gale whole woods were swept away, leaving only the carcases of trees. Such was the fate of the wood at Strathgarry, Killicrankie. (Photograph shown.) At the celebrated pass of Killicrankie the destruction is not so formidable as in some other parts, but still much of the summer beauty of the pass is now marred by the ugly gaps in what was before an unbroken mass of verdure (photograph shown).

In looking at the partial disfiguration of this historic spot, I was forcibly reminded of a similar catastrophe, in the classic broad walk at Christ Church College, Oxford, some 15 years ago. I obtained some photographs descriptive of the damage at the time, and, in conclusion, it may be of interest to show them to the Meeting. I am unable to remember the exact date of the

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storm. Mr. Stone, of the Radcliffe Observatory at Oxford, writes to me that he is under the impression that the date was October 14th, 1881, when the highest velocity recorded was 68 miles, but I have reason to believe it was an earlier date than this.

DISCUSSION.

Mr. C. HARDING said that it would be interesting to know in what general direction the trees lay on the ground. Judging by the movements of the depression which occasioned the gale, he presumed that it was the Northerly wind that caused the most destruction. The greatest hourly velocity (96 miles) recorded by the anemometer at Deerness, Orkney, during this gale was the highest ever known.

Mr. H. HARRIES said he had been informed by a gentleman who had been visiting the eastern districts of Scotland that the destruction of trees on that side was immense, but what was locally observed as the curious feature of the event was that the trees were laid from the North-westward, a very unusual direction for heavy gales in that district, being generally Southerly or South-easterly. It was, therefore, thought that the damage was due not so much to the strength of the wind as to the fact that the trees were struck on their weakest side. It will be remembered that this gale, which was at first from the normal Southerly direction, suddenly burst from the North-west quarter when the centre of the disturbance began to move Southward along the east coast of Scotland.

Mr. R. COOKE remarked that he had once observed a curious effect of a gale in a hop garden, no poles being disturbed round the edges of the garden, while in the middle they were blown down in all directions. This was considered to be due to the undulatory motion of the gale, and may perhaps account for the curious effect of a storm in a forest, one tree being taken and another left.

HISTORY OF A WATERSPOUT.

By ALFRED B. WOLLASTON.

(Communicated by ROBERT H. SCOTT, F.R.S.)

[Received July 12th—Read November 21st, 1894.]

SOME years since (1840 or 1841), when senior officer of the watch on board a large East Indiaman (the *Vansittart*), then in the eastern part of the Bay of Bengal, I noticed a peculiar disturbance of the water, which had the appearance of being forced up in innumerable small jets, covering an area of fully 400 yards in diameter, through which we were slowly passing with a light steady breeze only sufficient to give the vessel steerage way. The sky was absolutely cloudless. These jets rapidly increased in number and force, throwing up vapour, like steam, and seeming to revolve and draw towards a centre. When this action had continued for a short time, and a dense column of steam was rising, a small cloud became visible immediately above; its centre reaching downwards. When the two columns united a

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magnificent waterspout resulted, rapidly rotating. Dense clouds rapidly overshadowed us. Rain fell in torrents. The wind freshened for a short time and again fell light. In less than half an hour all symptoms of any disturbance had ceased.

One feature out of many others was, that the concentrating jets, although they had produced a pile of foam, did not immediately develop into a *visible* column. I venture the suggestion that, as with the cloud overhead, it was only by condensation of its circumfluent vapour that it became so. It was never so dense as to entirely obscure the horizon when viewed through a telescope. The interior seemed to be rising infinitely more rapidly than the exterior. Constant flashes of flame-like vapour were being violently whirled up.

I would mention that I know of one other instance of the sea being disturbed in a similar manner over a much larger area, but the jets did not gyrate and no waterspout resulted.

DISCUSSION.

Mr. R. J. LECKY, in a letter to Mr. Scott, said:—"Mr. Wollaston appears to be dubious as to the formation of this grand phenomenon. He suggests electricity, and so far, doubtless, he is right. I may, however, explain my views by an examination of this special case. The ship is, on a fine clear morning, in the eastern side of the Bay of Bengal (which in the rainy season is perhaps the wettest part of the globe), and with an upper atmosphere which, from the data you have kindly sent me, must have contained from eighty to ninety thousand tons of water, in solution, to each cube mile. An isolated mass of this atmosphere, many miles in extent, becomes electrified in a high state of tension, exactly as is the case in one of our common thunderstorms (the cloud formation being an after-consideration), and, in the same way, induces the contrary state in surface of the earth or sea: these two electric states approaching until the favourable place and time arrive for the discharge, when the upward current, meeting with resistance from the mobile sea surface, develops heat sufficient to cause the appearance of steam, which it carries with it as it ascends to join the other electric state. This latter descending, carries with it saturated atmosphere sufficient to form the small cloud, which is seen to meet the ascending current. The junction is then complete, condensation speedily follows, the black cloud is formed, and the descending electric current carries with it a dense column of rain, as a waterspout, confined to the comparatively small area of the point of discharge. The currents become mutually nullified, the actual column of water breaks up, and the discharge of rain becomes general. I alluded to our ordinary thunderstorms being produced in their early stages by similar causes to the above. When the electric influence is in a sufficient state of tension, the discharge is more acute, and when meeting resistance the heat, so instantaneously developed, produces those effects falsely attributed to the lightning flash, which itself is only an after result. Whirlwinds also are produced by the same cause, but the current is of much larger volume, and the intensity very much reduced. The mode by which these isolated masses of the upper atmosphere receive their charge of electricity is a difficult subject to put into simple form, but to those who have studied the action of the Leyden jar, or, better still, the coated sheet of glass (the same in principle), can easily understand how the electricity of the surface of the earth acts by induction on the upper atmosphere, producing the opposite state of electrical influence; and in this case the earth may, for the nonce, be considered as a grand electrical machine, and the dry lower atmosphere as the intervening di-electric."

Mr. R. H. SCOTT read the following notes on Waterspouts which had been extracted from unpublished ships' logs in the possession of the Meteorological Office;—

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AUGUST 20th, 1855, *Crest of the Wave*, Captain John Steele.—At 7 a.m., when in lat. 35°·50′ N., long. 19°·42′ E., or 188 miles W. ¼ S. from Cape Matapan, passed under a waterspout. At 6 a.m. heavy squall-like cloud forming at south east and north-west, a waterspout forming at east end of South-east squall, and another at west end of North-west squall, both squalls closing upon the ship. Up to this time the weather had been clear, with an almost cloudless sky and light but steady wind from West-south-west. All studding sails had been set during the night. At 6.30 took in studding sails and all light sails, hauled up courses, and stood by topsail haulyards and jib down haul. Waterspout now near at hand direct ahead, and coming fast upon us. Let fly topsail haulyards, and had got the jib about half down when it struck us on the port bow, filling staysail and jib to starboard but pressing fore yard far aback. In another instant filling head yards and pressing main yard aback and again throwing main and mizen yards full and aback at the same instant, whirling along port side with a violent gust and round the stern with a loud noise, throwing water into the stern windows as it passed. A moment after there was a calm, then heavy gusts succeeded by a heavy squall and much rain from east-south-east.

"The waterspout waved and bent to the whirling wind, and in its action was like a huge transparent chimney in which the water, 'smoke like,' was curling its way to heaven. I had time to view it, and was much struck with the curling vapour rolling up its glass-like tube. I have heard it stated that anybody passing through a waterspout would burst it; this one had half its base acting upon my ship, but still remained perfect in form and action."

OCTOBER 26th, 1855. *Medway*, Captain J. B. Kennedy, lat. 6°·18′ N., long. 24°·21′ W.—9 a.m. saw a strange circular motion of the water close to us; it was like an eddy in a tide way, or like the motion of the water in a whirlwind; it was going very slowly to the north, in the teeth of a faint air from the Northward. When about a quarter of a mile from us it turned into a regular whirlwind. I could not perceive any motion in the clouds, nor any sign of wind near it. About a quarter of an hour after this the wind flew round to the South-south-east in a sharp squall, with heavy rain."

DECEMBER 10th, 1858. *Medway*, Captain J. B. Kennedy, lat. 6°·7′ N., long. 85°·40′ E.—Several waterspouts about. They make up on the surface of the water, like a whale blowing, and then connect themselves with a cloud (nimbus) above them, leaving a break between them.

Mr. A. B. WOLLASTON remarked that Capt. Steel's account referred to the ascending motion of the spout, which coincides with what he (Mr. Wollaston) had noted.

Capt. D. WILSON-BARKER said that the best waterspout he ever witnessed most certainly descended, but he did not wish to imply from this that it was always so.

Capt. A. S. THOMSON stated that all the waterspouts which he had seen had occurred with a very cloudy sky, and when a large amount of condensation was in progress. He did not think that electricity played any part in the production of these phenomena, but considered that they were due to rapid condensation. Capt. Thomson then gave a description of the various processes which, from careful observation of waterspouts on many occasions, he thought it was probable took place when a waterspout was formed.

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The Report on Cloud Nomenclature, &c., presented to the International Meteorological Committee at Upsala, in August 1894.

By ROBERT H. SCOTT, M.A., F.R.S.,
Foreign Secretary.

[Read December 19th, 1894.]

The chief feature of the Upsala Meeting was the Report of the Committee appointed at Munich, to consider the question of the Cloud Atlas.

Of that Committee there were present at Upsala Prof. Hildebrandsson, Hofrath Dr. Hann, Prof. Mohn, Mr. A. Lawrence Rotch, and M. Teisserenc de Bort.

The following Members of the International Meteorological Committee were coopted with the Cloud Committee for the Meeting:—Prof. von Bezold, of Berlin, Director Billwiller, of Zürich, and Mr. Davis, of Cordoba.

In addition certain gentlemen present at Upsala were invited to join in the discussions, viz.:—Prof. Broounof, of Kieff, Dr. Fineman, and Dr. Hagström, of Upsala, Prof. Riggenbach, of Basle, Prof. Sprung, of Potsdam, and M. Weilbach, of Copenhagen.

The following are the Definitions and Instructions as finally adopted:—

The classification adopted is as follows:—

a. Separate or globular masses (most frequently seen in dry weather).

b. Forms which are widely extended, or completely cover the sky (in wet weather).

A. Upper Clouds, average altitude 9,000 m. (29,528 ft.).

a. 1. Cirrus.

b. 2. Cirro-stratus.

B. Intermediate Clouds, between 3,000 m. (9,842 ft.) and 7,000 m. (22,966 ft.).

a. 3. Cirro-cumulus.
   4. Alto-cumulus.

b. 5. Alto-stratus.

C. Lower Clouds, between 1,000 m. (3,281 ft.) and 2,000 m. (6,562 ft.).

a. 6. Strato-cumulus.

b. 7. Nimbus.

D. Clouds of diurnal ascending Currents.

8. Cumulus; apex 1,800 m. (5,906 ft.); base 1,400 m. (4,593 ft.);

9. Cumulo-nimbus; apex 3,000 m. (9,842 ft.) to 5,000 m. (16,405 ft.); base 1,400 m. (4,593 ft.).

E. High Fogs, under 1,000 m. (3,281 ft.).

10. Stratus.

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EXPLANATIONS.

1. CIRRUS (Ci.). *Detached clouds, delicate and fibrous looking, taking the form of feathers, generally of a white colour*, sometimes arranged in belts which cross a portion of the sky in "great circles," and, by an effect of perspective, converge towards one or two opposite points of the horizon (the Ci.-S. and the Ci-Cu. often contribute to the formation of these belts).

2. CIRRO-STRATUS (Ci-S.). *A thin, whitish sheet*, at times completely covering the sky and only giving it a whitish appearance (it is then sometimes called Cirro-nebula), or at others presenting, more or less distinctly, a formation like a tangled web. This sheet often produces halos around the sun and moon.

3. CIRRO-CUMULUS (Ci-Cu.). *Small globular masses or white flakes without shadows, or having very slight shadows, arranged in groups and often in lines.*

4. ALTO-CUMULUS (A.-Cu.). *Largish globular masses, white or greyish, partially shaded, arranged in groups or lines, and often so closely packed that their edges appear confused.* The detached masses are generally larger and more compact (changing to S-Cu.) at the centre of the group; at the margin they form into finer flakes (changing to Ci-Cu.). They often spread themselves out in lines in one or two directions.

5. ALTO-STRATUS (A-S.). *A thick sheet of a grey or bluish colour*, showing a brilliant patch in the neighbourhood of the sun or moon, and which, without causing halos, may give rise to coronæ. This form goes through all the changes like the Cirro-stratus, but by measurements made at Upsala, its altitude is one-half less.

6. STRATO-CUMULUS. (S-Cu.). *Large globular masses or rolls of dark cloud, frequently covering the whole sky, especially in winter*, and occasionally giving it a wavy appearance. The layer of Strato-cumulus is not, as a rule, very thick, and patches of blue sky are often visible through the intervening spaces. All sorts of transitions between this form and the Alto-cumulus are noticeable. It may be distinguished from Nimbus by its globular or rolled appearance, and also because it does not bring rain.

7. NIMBUS (N.). RAIN-CLOUD. *A thick layer of dark clouds, without shape and with ragged edge*, from which continued rain, or snow generally falls. Through the openings in these clouds an upper layer of Cirro-stratus or Alto-stratus may almost invariably be seen. If the layer of Nimbus separates up into shreds, or if small loose clouds are visible floating at a low level, underneath a large Nimbus, they may be described as Fracto-nimbus ("Scud" of sailors).

8. CUMULUS (Cu.). WOOL-PACK CLOUDS. *Thick clouds of which the upper surface is dome-shaped and exhibits protuberances while the base is horizontal.* These clouds appear to be formed by a diurnal ascensional movement which is almost always observable. When the cloud is opposite to the sun, the surfaces usually presented to the observer have a greater brilliance than the margins of the protuberances. When the light falls aslant, these clouds give deep shadows; when, on the contrary, these clouds are on the same side as the sun, they appear dark, with bright edges,

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The true Cumulus has clear superior and inferior limits. It is often broken up by strong winds, and the detached portions undergo continual changes. *Fracto-cumulus.*

9. CUMULO-NIMBUS (Cu-N.). THE THUNDER-CLOUD; SHOWER-CLOUD. *Heavy masses of cloud, rising in the form of mountains, turrets, or anvils, generally having a sheet or screen of fibrous appearance above ("false Cirrus"), and underneath, a mass of cloud similar to Nimbus.* From the base there usually fall local showers of rain or of snow (occasionally hail or soft hail). Sometimes the upper edges have the compact form of Cumulus, forming into massive peaks round which the delicate "false Cirrus" floats, and sometimes the edges themselves separate into a fringe of filaments similar to that of the Cirrus cloud. This last form is particularly common in spring showers.

The front of thunder clouds of wide extent frequently presents the form of a large bow spread over a portion of the sky which is uniformly brighter in colour.

10. STRATUS (S.). *A horizontal sheet of lifted fog.* When this sheet is broken up into irregular shreds by the wind, or by the summits of mountains, it may be distinguished by the name of *Fracto-stratus.*

INSTRUCTIONS FOR OBSERVING CLOUDS.

For each observation the following points are to be noted and entered in the register or schedule.

1. *The kind of cloud* indicated by the initial letters of the name of the cloud (for greater precision, the number of the plate in the *Atlas* which most nearly resembles the form observed, might be given [Example C. 3].)

2. *The direction from which the clouds come.*

By remaining perfectly still for several seconds, the movement of the clouds may easily be observed in relation to a steeple or pole erected in an open space. If the movement of the cloud is very slow, the head should be steadied by using a rest. This method of observing must only be used for clouds near the zenith, for if they are distant from it the perspective may lead to errors. In such cases the nephoscope must be used, and in each case the rules given for the kind of instrument in use must be followed.

3. *The point of radiation of the upper clouds.*

These clouds often take the form of narrow parallel lines, which by reason of the perspective, appear to issue from a given point on the horizon. The "point of radiation" is the name given to the point where these belts or their prolongations meet the horizon. This point on the horizon should be indicated in the same manner as the direction of the wind, N, NNE, etc.

4. "*Undulated clouds.*"

It often happens that the clouds have the appearance of regular striæ, parallel and equidistant, like waves on the surface of the water. This is mostly the case with the Cirro-cumulus, Strato cumulus (Roll-Cumulus), etc.

It is important to note the direction of these striæ. When two distinct

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systems are apparent, as is often seen in clouds separated into globular masses by striæ in two directions, the directions of these two systems should be noted.

As far as possible these observations should be taken of striæ near the zenith, so as to avoid errors caused by perspective.

5. *The density and situation of a bank of Cirrus.*

The upper clouds often assume the form of a tangled web or sheet, more or less dense, which as it appears above the horizon looks like a thin bank of a light or greyish colour. As this form of cloud is closely connected with barometrical depressions, it is necessary to observe: —

(a.) The density.

0 = very thin and irregular.
1 = thin, but regular.
2 = fairly thick.
3 = thick.
4 = very thick and of a dark colour.

(b.) The direction in which the sheet or bank appears thickest.

6. *Remarks.*—All interesting particulars should be noted, such as:—

i. During summer all lower clouds as a rule assume special forms, resembling more or less Cumulus. In such cases an entry should be made in the column for "Remarks," *Stratus*, or *Nimbus cumuliformus*.

ii. It sometimes happens that a Cumulus presents a mammilated lower surface. This appearance should be noted under the name of *Mammato-cumulus*.

iii. It should always be noted whether the clouds seem to be stationary or in very rapid motion.

DISCUSSION.

Mr. F. Gaster exhibited and described a number of lantern slides of clouds which he considered represented the various forms described in the Report.

Capt. D. Wilson-Barker said he would like to ask Mr. Scott if the primary classification was supposed to bear any relation to the names of the clouds which followed after. Were the altitudes given for certain latitudes, or for all the world? He very much doubted if there were any clouds above the "Nimbus." His own impression was that the "Nimbus" cloud was one that grew downwards. He would also suggest that the sun, moon, and stars were useful aids in determining the motion of clouds. He could not see how the density could very well be denoted by number. After a slight glance through the Rev. Clement Ley's monograph on the subject, he was convinced that his classification was in every way superior to that recommended by the International Committee. He could only consider that this proposed nomenclature was a slight advance on that of Luke Howard. He was very much interested in the able way in which Mr. Gaster fitted in the photographs to the proposed names, and thanked Mr. Scott for bringing the matter before them.

Hon. Rollo Russell said that he had read the report with great interest, but was unable without further examination to offer any criticism on the classification adopted. The limiting altitudes given appeared to be stated rather precisely, and he should like to know whether they were intended to represent absolute limits, or whether they were the result of an average of a number of observations. The heights of alto-cumulus and cumulo-nimbus would seem to stand for average altitudes, as these clouds were frequently observed with tops

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at a much higher level and with a lower base. Cirrus clouds were to be seen at greater heights than those usually given, and sometimes float, as balloon observations have proved, at higher altitudes than aeronauts have ever reached.

Mr. M. Jackson thought that it would be a useful arrangement if meteorologists who were in need of instruction in the methods of cloud observing, were to take excursions into the country under the guidance of a competent cloud authority, for the purpose of studying cloud formations. He had frequently noticed how greatly the clouds differed in various localities and countries. The prevailing clouds of Scotland were, in his opinion, quite distinct in form from those to be seen in the Isle of Thanet (where he had resided for the greater part of his life), and these latter were different from such as were common in the skies of Italy. Ruskin had stated that the finest sunset clouds visible in England were those to be seen in the Isle of Thanet; and he (Mr. Jackson) would like to know why the clouds common there should differ so greatly from those which were to be observed in Argyllshire, for instance. He had watched clouds over the Atlantic before the approach of a storm, and had seen them assume most remarkable forms. It would be interesting to have an explanation of the variation in the prevailing forms of clouds in different latitudes.

Mr. C. Harding said that from his experience in connection with the discussion of observations made at sea, he was sure that sailors would be grateful to the International Committee for the limited cloud nomenclature which had been adopted, the classification being only a just and wise extension of Luke Howard's. He was pleased that Mr. Gaster favoured it, as he (Mr. Harding) did not agree with the classification which Mr. Gaster had himself suggested a short time since. He could not agree with Capt. Wilson-Barker that Mr. Ley's nomenclature was superior to that embodied in the Report of the International Committee; and he was sure that the elaborate classification suggested by Mr. Ley would not do for ordinary use, as there was a great deal too much to master in it. The members of the International Cloud Committee were all men of good standing and thoroughly competent to accomplish the object for which the Committee was formed; consequently their proposals were likely to be readily accepted. He had compared the Committee's Report with the *Cloud Atlas* issued by Dr. K. Singer two or three years ago, and had been much surprised to see how closely the two agreed.

Mr. J. G. Wood thought that a series of successive pictures of cloud changes by means of photography would be most valuable, and a great aid to the successful study of cloud forms. There was no more difficult subject to photograph than a cloud, and he suggested that it was desirable that a set of simple rules should be drawn up for the guidance of any desiring to take up this interesting branch of scientific work.

Mr. Birt Acres said that his own observations of clouds had led him to conclude that there were really only two varieties—clouds which were formed near the earth, and those which were produced at high altitudes. As a result of the experience he had gained in cloud photography, he had found it necessary to adopt two systems, one being to employ a Nicol prism, and the other to use a black mirror, similar to that employed by Mr. Clayden. For cirrus clouds he had been obliged to use a plate very sensitive to the less refrangible rays, ordinary plates being practically insensitive to these rays, and often in addition to use a yellow screen as well as the polarising apparatus.

Mr. R. H. Scott said that the altitudes stated in the Report referred to Northern Europe, as the measurements upon which they were based were made at Upsala and Potsdam. Regarding Mr. Jackson's remarks concerning the differences in the cloud forms in different latitudes, the Hon. R. Abercromby some years ago read a paper before the Society in which he showed that cloud forms were identical all over the world. The difference between the clouds in the Highlands of Scotland and those in the Isle of Thanet was probably due to the great dissimilarity in the configuration of the ground in these two districts, Scotland being hilly, and Thanet flat, so that in the latter locality a better horizon was secured, and the conditions were more favourable for watching the progress of clouds. Mr. Scott also stated that the selection of typical pictures for the *Cloud Atlas* was carried out in as unbiassed a manner as possible, all names and marks of identification being removed from the photographs submitted for inspection by the Committee: and he stated his readiness to represent

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to Dr. Hildebrandsson the wish of the Meeting that some explanation of the methods of measurement should be introduced into the preface to the forthcoming Cloud Atlas.

METEOROLOGICAL OBSERVATIONS AT MOJANGA, MADAGASCAR, DURING 1892-1894.

By STRATTON C. KNOTT, H.M. Vice-Consul.

(Communicated by R. H. Scott, F.R.S.)

[Received November 28th.—Read December 19th, 1894.]

Mojanga is situated on the north-west of Madagascar, on the coast of Betsiboka Bay, in latitude 15° 48′ 0″ S, and longitude 46° 19′ 15″ E. Although the period over which these observations extend is but short, it has been thought the results obtained would be of interest in view of the scanty information we possess for the island.

The meteorological station is about 1 mile from the town, and stands on a plain 186 feet above the sea level. From south-east to south there is a view of Betsiboka Bay, and from south-west to north-west the open sea is visible.

The station itself is a piece of land about 100 yards long and 70 yards broad, given to me for the purpose by the Malagasy Governor. The exposure of the instruments is very good, there being no buildings to affect the readings, and but few trees near, and those but small. From the observatory plain the ground gradually slopes away. At 6 miles due north are the hills of Pajony, about 400 feet high.

The barometer is by Adie, and has an error of ·005 in.; its cistern is 140 feet above mean sea level. All the thermometers have been verified at Kew, and corrections have been applied for any errors. The rain gauge is by Casella; it is 8 inches in diameter, and its rim is 1 foot above the surface of the ground.

The observations were taken daily at 11 a.m. and 5 p.m. The dry and wet bulb thermometers by Messrs. Negretti & Zambra, and the maximum and minimum self-registering thermometers by Casella, are exposed in a screen under a shed which is open all round, is 4 feet from the ground, and has a ventilator. The values of the dew point, humidity, and vapour tension have been computed by Glaisher's *Hygrometrical Tables*.

All the instruments have been supplied by the Meteorological Council.

The solar radiation thermometer only arrived in September, and unfortunately the terrestrial minimum was damaged in transit, and had to be returned, but for the year 1894 the following instruments have been added

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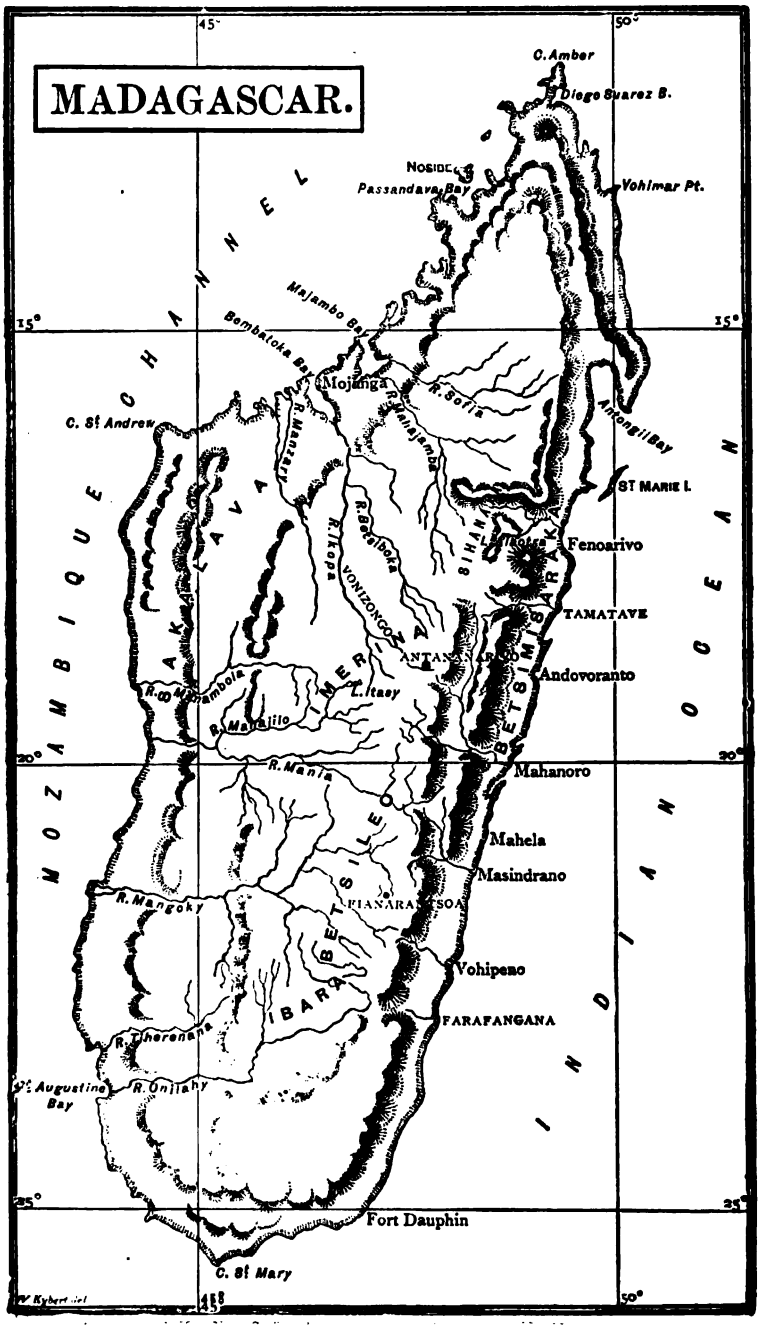

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to those already in use:—Cup and dial anemometer, by Casella; terrestrial minimum radiation thermometer, by Casella; two earth thermometers, for depths of 18 inches and 42 inches, by Troughton and Simms.

The observations began in April, 1892, and the accompanying tables are for the two years April, 1892, to March, 1894. The observations are still being continued.

Pressure.—The average pressure for the whole period was at 11 a.m. 30·039 ins., and at 5 p.m. 29·965 ins.; and the mean range between the two observing hours was therefore ·074 in. The highest mean pressure in any month (taking the mean of 11 a.m. and 5 p.m.) was 30·155 ins. in August, 1893; the lowest 29·842 ins. in January, 1893.

The highest absolute reading of the barometer was 30·265 ins. on July 19th, 1892, at 11 a.m., and the lowest reading was 29·689 ins. on January 23rd, 1893, at 5 p.m. Six days later, namely on the 29th, there was a strong gale from North-west, when the wind reached force 9, but the lowest pressure recorded during the gale was only 29·738 ins.

Temperature.—The mean temperature (mean of maximum and minimum) was 80°·2 in 1892-3, and 79°·1 in 1893-4, and for the two years 79°·7. The mean maxima ranged from 91°·4 in April, 1892, to 84°·5 in July, 1893, and the mean minima varied between 64°·9 in July, 1893, and 75°·1 in March, 1894. The absolute extremes were 98°·8 in November, 1892, and 60°·0 in January, 1893, a range of 38°·8.

In every month during the period except two (June and July 1893) the maximum temperature exceeded 90°, while in eight months the minimum did not fall below 70°.

The coldest month appears to have been July 1893, with 74°·7; while April 1892 was the hottest, with a temperature of 82°·9.

The depression of the wet-bulb was, as might be expected, large, the means ranging from 19°·1 at 11 a.m. in September 1892 to 5°·8 at 5 p.m. in January 1894, the means being in 1892-3 10°·6, and in 1893-4 10°·7. The highest individual difference reported was 24°·0 at 11 a.m. on October 23rd, 1892.

Hygrometry.—August and September are the driest months, with a vapour tension of from ·400 in. to ·500 in. and a relative humidity of as low as 34 per cent.

The mean difference in the vapour pressure at 11 a.m. compared with that at 5 p.m. is ·067 in., the value at 5 p.m. being higher by that amount; while the humidity is nearly 10 per cent. greater in the afternoon than in the middle of the day.

Solar Radiation.—Observations of the solar radiation were taken from September 1893 with a black bulb maximum *in vacuo*, and for the seven months till March 1894 the results show monthly means varying from 152°·4 in January to 157°·0 in February, with an absolute maximum of 177°·4 on February 7th.

A grass minimum was obtained and observations begun on January 10th, 1894. In the period of nearly three months the lowest temperature observed was 70°·0, on March 12th.

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RESULTS OF OBSERVATIONS MADE AT MOJANGA, MADAGASCAR.
Long. 46° 19′ 15″ E. Lat. 15° 43′ 0″ S. Height above Mean Sea Level 134 feet.

1892–3.	Mean Pressure at Sea Level.		Air Temperature.								Humidity.					
					Means.		Extremes.				Depression of Wet Bulb.		Tension of Vapour.		Percentage.	
	11 a.m.	5 p.m.	11 a.m.	5 p.m.	Min.	Max.	Min.	Date.	Max.	Date.	11 a.m.	5 p.m.	11 a.m.	5 p.m.	11 a.m.	5 p.m.
	ins.	ins.	°	°	°	°	°		°		°	°	in.	in.	%	%
April	29·971	29·904	87·2	85·8	74·4	91·4	70·1	30	95·3	5 & 25	11·2	9·1	·705	·754	54	61
May	30·072	30·005	84·4	83·3	70·5	88·8	68·0	22, 24, 31	92·2	8	13·1	11·0	·570	·617	48	54
June	·088	·024	82·0	81·6	68·5	87·5	61·4	24	91·9	12	14·2	12·5	·486	·530	44	49
July	·145	·078	81·4	80·5	68·2	86·9	64·1	28	90·5	22	15·3	12·4	·445	·511	41	48
Aug.	·091	·016	83·0	78·8	68·2	88·3	65·1	2	92·9	11	14·4	8·2	·500	·617	44	62
Sept.	·114	30·037	86·3	80·7	68·4	91·3	65·1	2	94·8	9	19·1	10·0	·429	·595	34	56
Oct.	30·054	29·982	86·7	80·7	72·6	90·1	69·9	2	97·0	15	15·1	7·6	·555	·683	44	65
Nov.	29·994	·929	87·2	82·3	74·1	90·6	70·2	2–9	98·8	16	13·8	7·9	·609	·712	46	65
Dec.	30·009	·933	84·2	82·8	73·4	87·9	70·2	11–25	94·1	31	8·5	7·4	·737	·745	63	67
Jan.	29·875	·809	83·5	81·6	73·0	86·0	60·0	28	92·8	15	7·4	6·0	·762	·775	66	72
Feb.	·960	·893	84·3	83·8	74·8	87·0	67·9	12	90·9	24	7·5	6·9	·781	·794	66	69
Mar.	29·952	29·880	84·3	84·8	73·6	88·1	70·5	6	92·7	24	8·4	8·2	·743	·767	63	64
Year	30·028	29·958	84·5	82·2	71·6	88·7	..	..	..	..	12·3	8·9	·610	·675	51·1	61·0

1892–3.	Amount of Cloud.		Rainfall.			Weather. No. of Days of					Wind. No. of Observations of								
				Greatest Fall.															
	11 p.m.	5 p.m.	Total.	Amount.	Date.	Rain.	Thunderstorms.	Clear Sky.	Overcast.	Gale.	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm.
			ins.	ins.															
April	2·4	2·8	2·45	1·41	9	4	3	16	3	1	6	3	S	9	4	10	3	17	0
May	0·2	0·5	..	..	..	0	2	28	0	0	1	0	1	13	13	20	2	11	1
June ...	0·9	1·3	..	..	..	0	0	22	0	0	0	0	10	21	11	13	0	3	2
July	0·8	2·4	0·01	0·1	28	1	0	23	1	0	3	3	15	8	13	10	0	7	3
August ..	1·3	1·6	..	..	..	0	0	23	0	0	8	5	8	6	4	8	2	21	0
September	0·8	3·3	0·07	·07	28	1	1	17	0	0	5	16	9	6	1	3	6	14	0
October .	2·2	2·6	2·71	1·64	30	5	5	17	4	0	13	9	3	2	1	4	16	13	1
November	2·5	3·5	3·40	2·21	20	6	9	16	0	0	15	3	4	3	2	1	18	13	1
December	6·6	6·3	7·14	2·22	22	12	21	2	8	0	28	5	1	0	1	0	2	18	7
January	7·4	7·7	20·64	4·13	29	18	17	2	17	1	24	3	3	0	2	3	5	23	1
February	6·3	5·6	6·17	1·69	16	11	16	3	7	0	10	7	3	1	1	2	7	22	3
March ..	6·0	5·9	14·67	2·75	5	13	20	2	5	0	23	5	4	9	1	6	3	9	2
Year....	3·1	3·6	57·26	..	..	71	94	171	45	2	136	59	69	78	54	80	62	171	21

Rainfall.—The rainy season extends from October to April, with a very striking decrease in amount fo February. The average total fall for the year is 54·59 ins., the monthly falls ranging from *nil* to 20·64 ins. in January 1893. May to September are dry months, and the three months June to August are practically rainless. Some heavy daily falls of rain are reported, the maximum being 5·43 ins. in January 1894, with two others of upwards of 4 inches.

During the two years there were 86 days in which the rainfall exceeded

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RESULTS OF OBSERVATIONS MADE AT MOJANGA, MADAGASCAR.
Long. 46° 19′ 15″ E., Lat. 15° 43′ 0″ S. Height above Mean Sea Level 134 feet.

1893-4.	Mean Pressure at Sea Level.		Air Temperature.								Humidity.					
					Means.		Extremes.				Depression of Wet Bulb.		Tension of Vapour.		Percentage.	
	11 a.m.	5 p.m.	11 a.m.	5 p.m.	Min.	Max.	Min.	Date.	Max.	Date.	11 a.m.	5 p.m.	11 a.m.	5 p.m.	11 a.m.	1 p.m.
	ins.	ins.	°	°	°	°	°				°	°	in.	in.	%	%
April ..	30·012	29·933	84·9	84·6	73·1	87·8	69·8	8	92·1	1	9·9	8·9	·698	·732	58	62
May ..	·073	30·025	83·7	82·3	70·7	87·4	65·2	26	91·7	2	11·9	9·1	·595	·665	51	60
June ..	·125	·049	80·3	79·6	66·4	84·7	61·1	26	87·9	28	14·0	11·1	·460	·534	44	53
July ..	·152	·078	79·8	79·8	64·9	84·5	62·0	11	88 6	29	14·4	12·7	·442	·488	43	48
August	·197	·112	82·9	81·6	66·0	87·4	63·3	28 & 29	90·7	19	17·6	13·9	·412	·489	37	45
Sept ..	·094	30·020	85·4	78·6	68·1	88·2	63·0	5	93·5	27	17·5	7·8	·458	·627	37	64
October	·048	29·969	86·0	80·7	71·8	88·4	66·2	6	94·4	20	14·5	7·6	·557	·683	45	65
Nov. ..	30·061	·973	86·6	81·9	72·8	89·1	69·1	8	93·9	17 & 18	14·9	8·4	·558	·683	44	62
Dec. ..	29·998	·912	84·2	82·4	74 2	86·7	70·2	14	92·2	16	8·9	7·0	·720	·752	61	68
January	·924	·853	82·7	82·0	73·7	85·6	71·0	10 & 16	91·3	8	6·5	5·8	·781	·794	70	73
Feb.	·934	·854	84·8	84·7	74·6	87·9	71·2	15	93·2	5	8·0	7·4	·775	·799	65	66
March..	29·965	29·887	85·3	85·6	75·1	88·6	72·3	26	95·5	4	9·0	8·5	·746	·775	61	62
Year ..	30·049	29·972	83·9	82 0	71·0	87·2	..	..	..	..	12·3	9·0	·600	·668	51·3	6·07

1893-4.	Amount of Cloud.		Rainfall.			Weather. No. of Days of					Wind. No. Observations of								
	11 a.m.	5 p.m.	Total.	Max.	Date.	Rain.	Thunderstorms.	Clear Sky.	Overcast.	Gale.	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm.
			ins.	ins.															
April	4·3	4·1	4·11	1·75	7	5	14	9	5	0	14	3	6	12	2	6	2	11	4
May ...	2·7	3·4	0·68	·49	12	3	4	17	5	0	2	1	6	16	11	9	1	15	1
June	1·0	2·3	..	..	..	0	0	19	0	0	0	2	7	21	7	10	2	10	1
July	1·5	3·7	..	..	..	0	0	17	3	0	1	3	10	26	8	5	5	3	1
August ..	1·3	5·0	..	..	..	0	0	8	0	0	1	9	17	16	3	2	0	11	3
September	1·2	2·2	0·32	·31	26	2	0	20	2	0	7	4	7	14	1	1	3	23	0
October ..	2·4	2·0	3·80	3·28	23	3	5	17	1	0	3	0	2	14	4	0	5	34	0
November	3·7	2·2	1·09	·60	28	5	3	13	2	0	2	3	0	11	4	1	5	34	0
December	6·0	5·9	11·68	4·64	5	11	12	3	10	0	10	1	3	2	1	1	4	39	1
January..	8·8	9·3	18·62	5·43	15	17	18	0	27	0	3	3	3	4	3	5	4	37	0
February	8·1	6·8	3 64	1·09	20	13	14	0	15	0	7	6	4	3	1	3	5	22	5
March ..	6·5	4·6	7·97	2·62	25	16	18	4	8	0	9	7	1	10	1	6	1	23	4
Year	4·0	4·3	51·91	..	..	75	88	127	78	0	59	42	66	149	46	49	37	262	20

one inch, on 17 of which the fall was 2 ins. and upwards: the number of rainy days was, however, in no case excessive. Even in the wettest months the days of rain did not exceed 18, while for the rainy season (October to April) the average in each of the two years was 10 per month.

Cloud.—The cloudiness followed the rainfall, being greatest in January, the month of the greatest rainfall, and low from May to September, the dry months. On the average of all months, 5 p.m. was slightly more cloudy than 11 a.m., and this was invariably the case in the dry season. The days

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of clear sky were numerous from April to November, but in December, January, and February, the sky was frequently overcast.

No hail was observed in the period under review, and there were but two cases of gale. Thunderstorms were common in the rainy season, the average number of days of thunderstorm from December to April being as high as 15. The highest number in any month was 21 in December, 1892. In two months, December 1892 and March 1894, sheet lightning was seen on as many as 27 days.

Wind.—The wind summaries show that the prevalent direction during the rainy season was North-westerly, while in the dry season (May to September) the wind was commonly between South and East. In 41 instances during the two years the wind was reported calm.

Antananarivo.

Observations have been regularly taken for several years past at the London Missionary Society's College at Antananarivo, and it may be interesting to note the difference between the results for the capital and those for Mojanga. The College is situated 4,700 feet above sea level.

The observations for 1894 are not yet available, but for the 21 months, April, 1882, to December, 1893, the comparative results are as follow :—

	Temperature.			
	Means.		Absolute.	
	Minimum.	Maximum.	Minimum.	Maximum.
	°	°	°	°
Mojanga	70·8	88·0	60·0	98·8
Antananarivo	52·9	68·1	40·0	86·5

The rainfall-measuring glass was stolen in August, 1892, and was not replaced till January, 1893. The rainfall values therefore are only available for the purposes of comparison for the period April to July, 1892, and January to December, 1893. For this 16 months the results are :—

	Rainfall for 16 months.			
	Total.	Maximum.	No. of Rainy Days.	Days with 1 inch and upwards.
	in.	in.		
Mojanga	65·62	4·64	76	23
Antananarivo	59·13	4·70	108	21

These notes have been entirely drawn up by Mr. J. A. Curtis, of the Meteorological Office.

It will no doubt be interesting to append a summary of the observations taken at the College, extracted from *The Antananarivo Annual*. For the years prior to 1887 the annual quantities of rain are all that are given; with that year the publication of monthly totals of rain, as well as of extreme temperatures, was commenced.

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MAXIMUM AND MINIMUM TEMPERATURES AT ANTANANARIVO, MADAGASCAR.

Month.	1887.		1888.		1889.		1890.		1891.		1892.		1893.		Mean.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
January	70·9	68·1	77·0	60·4	75·7	60·6	77·0	59·5	74·4	57·2	76·4	58·7	74·4	56·7	75·1	60·2
February	73·9	65·1	77·9	61·1	77·3	61·8	76·5	60·2	76·0	59·3	74·1	59·8	72·9	57·3	75·5	60·7
March ..	75·5	64·3	72·6	57·9	73·7	59·8	73·9	59·0	70·7	57·2	72·2	57·3	71·5	56·0	72·9	58·8
April	69·9	57·4	68·8	55·6	70·1	57·5	70·2	57·3	67·8	55·8	69·5	56·0	67·3	54·3	69·1	56·3
May	66·5	53·7	68·8	53·8	67·0	53·0	63·0	50·9	63·3	50·2	62·8	49·8	63·0	51·8	64·9	51·9
June	60·8	46·1	63·8	50·5	61·5	48·1	58·9	45·6	61·2	47·7	58·5	46·9	60·6	50·9	60·8	48·0
July	61·6	48·0	61·7	48·6	61·7	47·8	59·7	47·1	58·7	45·5	58·8	45·4	57·4	44·4	59·9	46·7
August ..	61·9	46·6	62·5	48·9	61·4	47·9	62·0	47·1	60·3	45·3	63·6	47·6	62·4	48·9	62·0	47·5
September	67·1	50·3	68·6	51·2	67·1	50·2	64·6	48·1	66·0	49·7	63·4	46·1	69·4	58·6	66·6	50·6
October ..	71·8	55·1	73·5	56·2	70·3	53·2	70·4	52·2	71·5	53·7	72·3	51·5	75·4	61·8	72·2	54·8
November	77·1	57·1	75·7	58·2	76·6	57·4	73·5	56·0	74·3	54·8	74·8	54·0	76·7	55·3	75·5	56·1
December	75·3	57·6	77·7	60·8	77·9	59·3	73·6	57·0	77·9	58·3	76·0	56·9	79·4	60·4	76·8	58·6

YEARLY RAINFALL.

1881.	1882.	1883.	1884.	1885.	1886.
42·12	41·08	57·65	68·86	52·19	47·28

MONTHLY RAINFALL AT ANTANANARIVO.

Month.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	Means 1887–1893.
	in.	in.	in.	in.	in.	in.	in.	in.
January	17·56	9·56	11·26	7·04	3·35	16·31	11·67	10·96
February	14·28	6·73	11·98	7·55	8·11	10·89	11·30	10·12
March	9·87	9·62	6·32	4·14	11·10	1·09	5·87	6·86
April	·43	3·07	1·87	6·15	·94	1·79	3·41	2·52
May	2·12	·02	...	·04	·08	·10	2·38	·68
June	...	·15	1·11	·51	·06	·19	·42	·35
July	·43	·05	·13	·12	·12	·03	·35	·18
August	·52	·19	·27	·10	·06	·46	·03	·23
September	2·43	1·64	·46	·07	·15	·17	·03	·71
October	2·34	2·17	·39	4·90	10·84	2·21	1·97	3·55
November	7·05	10·57	4·25	7·43	·83	2·96	·60	4·81
December	7·95	7·28	11·71	14·67	6·75	11·07	18·98	11·20
Year	64·98	51·05	49·75	52·72	42·39	47·27	57·01	52·17

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FLOODS IN THE WEST MIDLANDS.

By HENRY SOUTHALL, F.R.Met.Soc.

[Received December 13th.—Read December 19th, 1894.]

The great interest now taken in the subject of river floods, no doubt increased of late by published accounts of circumstances attending the recent remarkable overflow of the Thames and other rivers in November last, may furnish some reason for placing on record the result of observations extending over a considerable number of years.

Since the subject of "Floods on the Thames" is likely to be dealt with at an early date by Messrs. Symons and Chatterton, the present paper will refer almost exclusively to those of the rivers Severn, Wye, and Usk, with some additional reference to the floods at Bath, caused by the Wiltshire Avon.

The term "West Midlands" may be considered to mean Herefordshire and the adjoining English and Welsh counties.

One other preliminary remark. When I offered at the last Council Meeting to give some information, partly from my own observation and partly what I may have gained from other sources, it did not at the time occur to me that the interesting paper[1] read by Messrs. Marriott and Gaster on the Floods of May 1886 had already given many particulars and facts relating to our Western inundations, which I had the pleasure of furnishing. I shall therefore endeavour to avoid needless repetition.

The accompanying map gives some idea of the geographical features and boundaries of the districts referred to, and has been copied from the *Ordnance Survey Map of the Rivers in England and Wales.*

The following table gives the area in square miles of the several basins, the length of their main streams, and also that of their principal tributaries. For comparison, similar details are furnished for the Thames, Trent, and the Yorkshire and Bedfordshire Ouses, which are the only other rivers in England as large as the Wye.

It must be borne in mind that the different rivers vary very much in their characteristics, and that the amount of water discharged in proportion to the distance traversed, or the area drained, is much greater in some than others, especially in time of flood. This, no doubt, depends mainly upon the quantity of rain falling in each district; but the conformation of the ground, and the receptivity of the soil, are also important factors. Even if we can ascertain, with a good degree of precision, the amount of deposit in the shape of rain or snow upon a certain area per square mile, it is surely exceedingly difficult to say how much of this finds its way into the rivers. The previous state of the ground, as regards saturation, will affect the

[1] *Quarterly Journal*, Vol. XII. p. 269.

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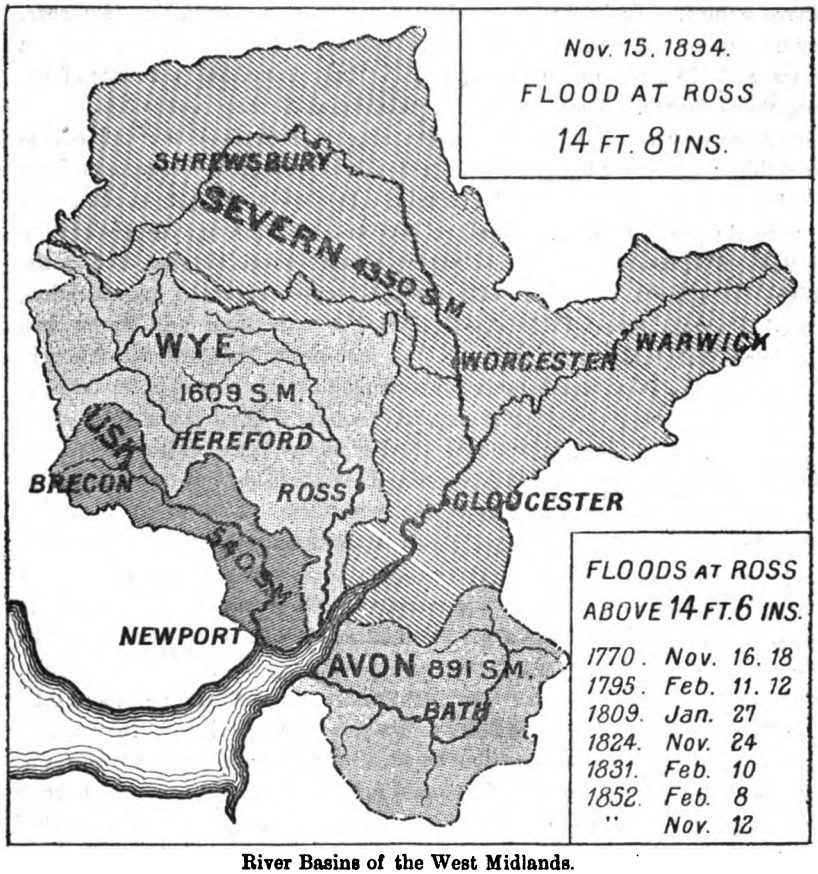
COMPARATIVE TABLE SHOWING AREA DRAINED BY THE RIVERS NAMED, WITH THEIR LENGTHS IN MILES.

River.	Catchment Basin, Area Sq. Miles.	Length Main Stream, in Miles.	Total Tributaries, in Miles.	Principal Tributaries, with lengths of each.
Thames	4,613	111	541	Lea, 50; Kennet, 45; Cherwell, 40
Severn	4,350	158	446	Avon, 85; Teme, 64
Trent	4,052	147	386	Derwent, 54; Meden, 42
Ouse (Bedfordshire) ...	2,607	143	178	Branden, 38; Cam, 30
,, (Yorkshire)	1,842	65	258	Swale, 64; Ure, 54; Nidd, 47
Wye (Herefordshire)	1,609	135	182	Lug, 40; Ithon, 29; Arrow, 26; Irven, 21
Avon (Wiltshire).....	891	62	29	
Usk	540	65	..	None of any consequence
Total	20,504	886	2,020	



River Basins of the West Midlands.

amount of percolation into it; evaporation at the same time varying with different conditions of wind, dryness of the air, and temperature. Of course it is easy to compute, approximately, the volume of water carried down by a

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river in flood, at any particular point or bridge, where the width of the river, the depth of the stream, and the speed of the current is known; but it is not so easy to ascertain how much of the total rainfall will at any time descend along the watercourse. A comparison of the different drainage areas tabled will show that the Severn stands midway in extent between the Thames and Trent, and that the Yorkshire Ouse is slightly greater than the Wye; while there is not much difference in the length in miles of the main streams of the Severn, Wye, and Trent—that is, excluding tidal portions of each.

The rivers Severn and Wye, rising within a very short distance of each other in the Welsh Mountains, near the summit of Plinlimmon, where the rainfall is probably double that of the districts where the Thames, Trent, or Ouse have their sources, are consequently subject to higher, if not more frequent, floods; and in proportion to their drainage area a relatively greater amount of water flows down them than is the case of the more eastern rivers above named. Probably the catchment basin of the Wye, acre for acre, receives more water than even that of the Severn; for the latter, taking a more easterly course than the Wye, gets away from the influence of the mountains sooner. The Wye, on the other hand, flowing southward at first, taps some very wet districts in its upper reaches in Radnorshire and Brecknockshire; including the one from which the Birmingham Corporation have elected to obtain their new water supply. The Black Mountains also, with an extent equalling that of a small county, and having a maximum elevation of 2,660 feet, drain both on their northern and eastern watersheds into the Wye. In addition to this, an extensive plateau of somewhat less elevation, called Radnor Forest (2,166 feet), drains into the Lug and Arrow, two important tributaries which join the Wye just below Hereford. Further in the case of the Wye, the distance from source to sea is only about two-thirds that of the Severn; consequently the fall per mile is greater, and the current more rapid. For the first 50 miles the bed of the Wye is also very rocky. These may appear to be mere geographical details, but they to some extent explain differences in the conduct of the two rivers.

And now, before dealing specially with the flood of November last it may be well to state the authority for doing so, and also the mode of obtaining information. This is derived principally from personal observations made at various times from the year 1886 to the present date 1894. I have visited most of the known sites where flood marks or gauges exist, some of them repeatedly. And in this connection, may I be allowed to express the wish that more care may be taken in the future than has sometimes been exercised in the past, as to the choice of place on which to fix such gauges or indicators. First of all, I would recommend that they should not be just where the greatest rush of the water is, otherwise it will be difficult to ascertain the exact height of the level reached; the splash often reaching quite a foot above that mark. And, secondly, that it is important that the record should be as permanent as possible. In many cases flood marks are made by notches on door-posts, trunks of trees, &c.; and in other cases roughly painted or chalked on a

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wall, with the result that they quickly become illegible. The brass plates let into the Cathedral steps at Worcester are models in this respect, those recording the height of the great floods in 1672 and 1770 being as clearly distinct as the day they were placed there.

It is also important, if possible, to have records of successive floods in closely adjoining places for sake of comparison—thus, for instance, at Worcester the mark of the great flood of 1795 is out of sight of, and a long way from the others just mentioned. At Hereford some are above and some below Wye Bridge, and quite out of sight of each other. In very high floods, by observing both, a comparison may be made, but at other times it is not possible to do so except by levelling. Very few flood marks are to be found in the higher parts of rivers, presumably because the flood does not rise so high, and soon runs off.

At Gloucester some interesting ones have within a few years been destroyed and removed. People seem very slow to learn the real practical utility of preserving them, and in this respect we are far behind some continental countries.

At Ross a rope maker, whose "rope walk" was likely to be flooded, marked accurately the height attained by the extraordinary flood of 1795, and also of many subsequent ones. He gave me before his death, at the age of 98, many of his recollections and experiences. Another intelligent boatman, who lived to a good age at Monmouth, could point to a stone in the bridge reached by the flood of 1809, the highest in *his* recollection. But such instances of thoughtful and accurate register are not frequent. On the lower side of Wilton Bridge, near Ross, there are several old flood marks, but many are now illegible. Those, however, with RH 73, RH 1795, cut into the stone are still decipherable. At Coalbrookdale there are quite a number of flood records on the gates of the old warehouse by the Severn side, which seem to be fairly accurate.

On the river Teme, we are greatly indebted to the late Mr. Davis, of Orleton, for his observations of rainfall since 1831, with the amounts registered on the few days previous to most of the principal floods for a considerable length of time, and also for the information collected by him as to those of 1770, 1795, 1809, 1821, &c.

I have also carefully searched the files of old county newspapers, specially those printed in the county towns of Shrewsbury, Hereford, Worcester, and Gloucester. It is not always that the accounts given in these papers contain sufficiently definite information to be of any value; such expressions as "greatest in living memory," "highest ever known," being sometimes used only a few years after a much greater flood. As a matter of fact, few persons' memories are to be trusted either as to height, or exact dates, the latter often being at least one year wrong. But where it is stated that the flood reached to within so many inches of another, some evidence is afforded of careful noting and accuracy. Many interesting particulars, however, are in my possession of incidents occurring in these floods, such as the destruction of bridges (a great many having been carried away in 1795,) the

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stoppage of high roads and consequent delay of traffic, and also exciting accounts of drownings, loss of cattle, &c. The following from the *Hereford Journal* of 1770 is amusing. In reference to the overturning of the London stage waggon near Ross (coaches did not commence running till 1774), the quaint chronicler of that date says: "It is pleasant to reflect that the passengers were all got out before the accident happened."

Floods at Ross.

In reference to floods at Ross, I have found it convenient to sort them roughly into three classes:—

Primary or highest, all that are 14 ft. 6 ins. and more above summer level.
Secondary, those with a height of 12 ft. to 14 ft. 6 ins. ,, ,, ,,
Tertiary ,, ,, 10 ft. to 12 ft. ,, ,, ,,

Of these, none of the first have happened since November 12th, 1852, the previous instances of primary floods having been the following:—

1770—November 16th to 18th.
1795—February 11th to 12th.
1809—January 27th.
1824—November 24th.
1831—February 10th.
1852—February 8th.
1852—November 12th

Very high floods, however, occurred on the Lug and Teme on the following dates:—

1815—Date not given.
1821—September 9th.
1836—November 30th.
1839—July 31st.

The two last were of the highest class, but I find no record of them on the Wye. That of 1839 was very high on the Severn.

In reference to these highest floods, it may be noticed that they all occurred in November or February, except that of 1809, which was at the close of January. It would also appear that very high floods are not nearly so frequent as in former years, particularly on the Wye. The reason for this may be, that with better drainage the flood in the lower reaches of the river is carried off before the upper flood arrives, and more quickly than formerly. Railway embankments and additional bridges are supposed by some to "keep back" the water. At any rate, we can scarcely attribute the decrease to diminished rainfall.

These floods seem to be due to at least three different causes. Firstly, to an atmospheric condition which seldom exists except in the period November to March inclusive. A strong South-westerly to Westerly gale—an extra violent one is said by the boatmen to "over blow" the hills, and an Easterly or Southerly one does not produce much effect on the river—a great rise of temperature, rapidly melting accumulated snow, whilst at the same time heavily-charged clouds, fresh from the Atlantic, driven against the cold mountain slopes, precipitate their moisture in the shape of very heavy rain. In the case also of the break up of a long severe frost, the masses of ice brought down with the flood, and choking or blocking up the arches of these bridges. When these conditions are combined, as in 1795, there occurs a

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maximum flood. In 1814, when the memorable frost temporarily gave way in the beginning of February, the flood did not rise so high as in 1795 by about 8 feet, because the rise of temperature was not great enough to produce the same effect. Somewhat similar cases to 1795 occurred in February 1831 and February 1852, as well as in January 1809; whereas 1814 may be paralleled in 1838, 1855, 1878, 1879, 1881, and 1891, in each of which cases the Wye was firmly frozen all across, which is a very exceptional circumstance in so rapid a river.

Another condition also illustrated by the examples given of primary floods is one which often occurs in November, and that is the continuance of rains both in the mountain and lowland districts, till the soil becomes completely saturated. After this, three or four days' heavy rain will produce a great flood. Those in November 1770, 1824, 1836, 1852, and 1875 are typical instances, all of these having occurred about the middle of the month.

The third and last condition is that of heavy thunderstorms or cloudbursts, or the occurrence of very heavy partial or local rains. These are the cause of most of our summer floods. In May 1886 and July 1875, heavy downpours, without much apparent electric disturbance, produced locally extraordinary risings of the neighbouring streams. Of this character, too, was the great flood in Yorkshire, October 16th, 1892.

In the case of the waterspout or cloudburst in Breconshire, July 9th, 1853, the Usk rose to an unprecedented height, far beyond that of any previous time, houses being carried away and much damage being done, owing to the water coming down so suddenly and unexpectedly. An inscribed stone shows the height attained.

On May 27th, 1811, a storm broke over the country to the eastward of Hereford, lasting from 3 to 8 p.m., accompanied by torrents of rain. The Severn, at Worcester, is said to "have risen 6 feet in one hour, and 20 feet in twenty-four hours." On July 5th and 7th, 1852, violent thunderstorms occurred in the same district, which were said to have "carried everything before them."

On August 13th, 1858, 2·75 ins. of rain fell in 50 minutes; 3·84 ins. in 24 hours. The streets in Ross were flooded to a depth of 3 feet. On June 4th, 1891, four miles from Ross stone walls were swept down, and soil and crops removed from fields, from the enormous downpour over a very limited area.

Of summer floods affecting the larger rivers, the most notable examples are those of August 1799 and 1839, and July 1872. In each case large quantities of hay were washed down stream; 1839 being the most remarkable instance.

Floods of November 1894.

And now as to the recent flood of November 1894. The deficiency of rainfall, which commenced in Herefordshire in 1887, continued with a few breaks till October 22nd, 1894. The accumulated defect, taking the previous twenty years 1867-1886 as a standard of comparison, being as much as 42·85 ins., or equal to the average fall in 16 months. On October 23rd,

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however, the rain which occasioned the flood set in, and by the 31st, that is in nine days, 6·78 ins. fell at Rhayader (Nantgwylt), near the source of the Wye, and 4·43 ins. at Ross, which is nearly a maximum record in the time for the latter place. On October 28th the river had only risen 7 feet. On November 2nd a height of 10 feet was shown by the gauge. There was then a fall, and it was not till after the renewed rain of November 11th to 14th, producing about 2 ins. of water more, that the Wye rose to 12 feet. From this time the river continued to rise till, at 8 p.m. on the 15th, a height of 14 feet to 14 feet 3 inches was reached, a limit which had scarcely been exceeded since November 1852, although several instances of floods of similar height had occurred in the interim. During the next 12 hours the water fell 22 inches, and then pretty quickly subsided, so that the river was contained again within its usual high banks. The lower or old road from Hereford (a new one was made after the coach had been left there in the flood in 1881) was impassable, and the whole valley, as seen from the Ross Prospect, was one wide lake. But little damage appears to have been done, nor much inconvenience caused, comparatively speaking.

I append tables showing the rainfall in different places, and also comparative heights of different floods as far as can be ascertained (pp. 36-38). More exact levellings are still needed to fix a good datum line, and it is hoped that before long there may be a more permanent set of flood-marks fixed in a conspicuous and suitable place, so as to make future comparisons more easy and simple. Further observations are also needed, so as satisfactorily to settle the difference of time between the top of the flood at different places on the river, speed of current, &c. It will be seen by these figures that the recent flood, though high, was not exceptionally so on the Wye, nor does it appear to have been so on the Severn, whilst on the Thames and Avon it was probably the highest of the century.

The following from *Keene's Bath Journal*, dated November 17th, 1894, gives a graphic account of the flood there :—

"All previous records in the way of floods have been beaten this week by the double disaster of Tuesday and Thursday. The flood of 1882 has hitherto been acknowledged to be the most disastrous of the century, though the water in 1809 is believed to have reached a few inches higher. This week, however, will be memorable in local history for having produced two floods, the latest quite eclipsing that of which any known record exists. The water reached its highest point at 3·30 a.m. Thursday, November 15th, and it then measured about a foot higher than 1882." It further on adds: "The flood level of 1882 is shown by a stone let into the wall, though the mark upon it was *not visible* owing to the growth of weeds." This in only 12 years! The account continues: "Several previous visitations stand out in the records of the century. The flood of 1809 was only a few inches above the level of 1882. It was caused by a heavy fall of snow followed by rain and consequent sudden thaw." Two horses attached to a coach were drowned at Batheaston in this flood. Then came the flood of 1821, then that of 1823 (? 1824), and afterwards 1828. This was the effect of a violent thunderstorm in July. "In this case a reservoir burst its banks. In 1841 two bridges were swept away. In 1866 the river rose 14 feet. In 1875 there were two floods, one in January, and one in November, 15 feet being the height of the latter. A similar one in January 1877. In 1878 a waterspout burst over Weston; that of October 24th, 1882, being the next except one in 1881."

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To return to the Wye, Mr. S. C. Lewis writes me from Elan Valley, Rhayader, "The heaviest flood of this year (1894) took place on the night of July 24th. Rain set in at 2 p.m., and next morning No. 2 gauge showed a fall of 3·57 ins.," the rainfall at Ross for same time being 0·59 in. This is similar to my experience at Dolgelly on October 6th, 1874, on which occasion 3·75 ins. fell between 9 a.m. and midnight, against 0·55 at Ross.

Historic Floods.

I may perhaps be allowed to conclude this imperfect account of floods in our own times by some short reference to historic floods. I have not included any of the "secondary" ones since 1852, except that of 1894, and the "tertiary" are too numerous to mention, although in some of these last a large body of water comes down, flooding the meadows to a depth of nearly 2 feet. I append a list of approximate heights and dates of the "secondary" since 1852 (p. 38).

The first flood on the Severn of which we have any account occurred 14 A.D., followed by one in 115 A.D. and 852 A.D., or three during the Roman period—much people and cattle said to have been destroyed.

During the Saxon period there are again three records—487, 813, 1046.

In 813 the chronicle says "2,000 people and 7,000 cattle lost." Many of the records in the next 400 years speak of inundations, but in many cases it is not stated whether they were produced by sea or river. But in 1483 Hollinshead says:—

"In October the River Severn overflowed for 10 days, and carried away men, women, and children in their beds, and the flood was called 'the great waters' for a hundred years after."

In like manner we now look back on the great flood of 1795, just a hundred years since.

Hume gives more particulars:—

"But at that time there happened to fall such incessant rains, so heavy and continued, as exceeded anything known in the memory of man, and the Severn and other rivers in the neighbourhood swelled to a height which rendered them impassable."

This flood put an end to the Duke of Buckingham's insurrection.

In 1607 "a strong West wind caused such a flood in the Severn that in several towns and villages the waters rose higher than the house tops."

So that great floods are nothing strange. If the calculation be a correct one that in 48 hours during November 1894 a cubic mile of water fell over England south of the Humber, we may be thankful not to have suffered more than we have done.

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RAINFALL IN WYE VALLEY AND BORDERS, OCTOBER 23RD TO NOVEMBER 14TH, 1894.

Station.	Pontsaill, 3 miles S. of Ross.	The Graig, Ross.	Burghill, Hereford.	Farm, Leominster.	Lynhales, near Kingston.	Orleton, Tenbury.	Penybont, Radnor.	Nantgwyllt, Rhayader.	Clifton, Bristol.
Observer.	W. E. Hancock.	H. Southall.	Dr. Chapman.	Miss Southall.	S. Robinson.	T. H. Davis.	J. Hamar.	V. C. Lewis.	R. F. Sturge.
	in.	in.	in.	in.	in.	in.	in.	in.	in.
October 23	·44	·46	·42			·41	·66	1·22	
24	·80	·80	·41			·36	·60	·65	
25	·20	·22	·10			·30	·14	·27	
26	·94	·83	·76			·83	1·28	1·02	
27	·37	·31	·06			·77	·34	·56	
28	·40	·50	·20			·19	·60	1·03	
29	·25	·13	·03			·08	·25	·33	
30	1·15	1·08	·74			·52	·50	·75	
31	·14	·10	·05			·05	·17	·95	
November 1	·15	·12	·20			·21	·37	1·27	
2	·05	·07	·06			·05	·18	·18	
3	·25	·07	·22			·20	·28	·35	
4	·28	·01	·09			·02	·10	·18	
5	·02	..	·02			·01	..	·01	
6	..	..	·07			·01	·04	·10	
7	·42	·36	·46			·33	·40	·60	
8	·22	·24	·22			·17	·26	·21	
9	·02	·02	·02			·04	·02	·07	
10	·23	·12	·08			·10	·38	·82	
11	·20	·19	·13			·06	·15	·22	
12	·78	·62	·82			·92	·74	1·10	
13	·99	·83	·87			·82	1·07	1·89	
14	·40	·31	·24			·21	·05	·09	
Total October 23 to November 24	8·70	7·39	6·27	7·09	8·06	6 66	8·58	13·87	8·50
Total October 23 to 31	4·69	4·43	2·77	3·39	4·00	3·51	4·54	6·78	3·30
„ November 1 to 10	1·64	1·01	1·44	1·50	4·06	1·14	2·03	3·79	5·20
„ „ 11 „ 14	2·37	1·95	2·06	2·20		2·01	2·01	3·30	

Daily particulars not to hand. Ditto.

RAINFALL AT BATH.

Previous to the two great floods, October 24th, 1882, and November 15th, 1894.

1882.	ins.	1894	ins.
Total 30 days previous to Oct. 18	3·59	Total 30 days previous to Nov. 8	4·18
Oct. 18	·15	Nov. 8	·19
19	·12	9	·08
20	·10	10	·23
21	·42	11	·81
22	·62	12	1·14
23	1·12	13	·79
24	·32	14	·61
Oct. 18 to 24. Total 7 days	2·85	Nov. 8 to 14. Total 7 days	3·85
Sept. 18 to Oct. 24. Total 37 days	6·44	Oct. 9 to Nov. 14. Total 37 days	8·03

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RAINFALL AT ORLETON, WORCESTERSHIRE.

Records of late Mr. T. H. DAVIS of Rainfall previous to great floods on River Teme.

				in.
1836.	November	28	...	·40
	,,	26	...	·15
	,,	27	...	·35
	,,	28	...	·79
	,,	29	...	·24
				1·93

				in.
1839.	July	26	...	·25
	,,	27	...	·07
	,,	28	...	·01
	,,	29	...	·65
	,,	30	...	1·50
				2·48

				in.
1852.	November	4	...	·42
	,,	5	...	·29
	,,	6	...	·28
	,,	7	...	·40
	,,	8	...	·18
	,,	10	...	·90
	,,	11	...	1·49
	,,	12	...	·43
				4·89

				in.
1886.	May	10	...	·14
	,,	11	...	·28
	,,	12[1]	...	2·23
	,,	13[1]	...	2·12
	,,	14	...	·01
				4·78

[1] Largest on two successive days in 56 years. Nearest to it in July 1834 (four days) 4·59 ins.

RAINFALL AT ROSS.

Previous to great floods on the Wye.

				in.
1852.	November	4	...	·92
	,,	5	...	·40
	,,	6	...	·72
	,,	7	...	....
	,,	8	...	·32
	,,	10	...	·25
	,,	11	...	1·37
	,,	12	...	·69
				4·67

				in.
1853.	July	7	...	2·20
	,,	9	...	·40
	,,	10	...	·49
				3·09

				in.
1867.	March	17	...	·31
	,,	18	...	·26
	,,	21	...	·45
	,,	22	...	·10
	,,	23	...	·83
	,,	24	...	·08
	,,	25	...	·58
				2·61

				in.
1869.	December	14	...	·42
	,,	15	...	·72
	,,	16	...	·03
	,,	17	...	·87
	,,	18	...	·23
	,,	19	...	·93
				3·20

				in.
1872.	July	6	...	1·31
	,,	7	...	1·46
				2·77

				in.
1875.	November	5	...	·73
	,,	6	...	·04
	,,	7	...	·59
	,,	8	...	·03
	,,	9	...	·77
	,,	10	...	·65
	,,	11	...	·01
	,,	12	...	·48
	,,	13	...	1·19
				4·49

				in.
1876.	December	26	...	·47
	,,	27	...	·24
	,,	28	...	·19
	,,	29	...	·52
	,,	30	...	·76
	,,	31	...	·63
1877.	January	1	...	·10
	,,	2	...	·35
	,,	3	...	1·02
				4·28

				in.
1880.	October	25	...	·12
	,,	26	...	1·27
	,,	27	...	·73
	,,	28	...	·11
				2·23

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RAINFALL AT ROSS—*Continued.*

			in.
1880.	December 27	...	·50
	,, 28	...	·28
	,, 29	...	·44
	,, 30	...	·59
			1·81
1886.	May 10	...	·18
	,, 11	...	·28
	,, 12	...	1·70
	,, 13	...	1·40
			3·46
1894.	November 11	...	·19
	,, 12	...	·62
	,, 13	...	·83
	,, 14	...	·31
			1·95
	Previous 19 days		5·44

COMPARATIVE HEIGHT OF FLOODS AT DIFFERENT PLACES.

Ross.

Assuming the height of the late flood at Ross to have been 14 ft. 3 ins. above lowest summer level of 1868, the following are approximate (say within an inch or so) comparative levels of highest reached, ranged in order, from greatest downwards:—

1770, November 18. No record, but said to be not quite equal to 1795 on Wye.

		ft.	in.			ft.	in.
1795	February 12	17	9	1877	January 1–2	14	3
1809	January 27.....	17	3	1881	February 11	14	3
1824	November 24	17	3	1880	October 29	14	3
1831	February 10	17	3	1875	November 15	14	3
1852	,, 8	16	10	1886	May 14–15	14	2
1852	Novembor 12	16	2	1880	December 31	13	10
1894	,, 15	14	3	1878	November 12	13	9
1867	March 24	14	3	1872	July 8[1]	12	6
1869	December 19	14	3				

[1] Very high for Midsummer Flood.

For comparative heights of floods at Worcester, Gloucester, &c. see *Quarterly Journal*, Vol. XII, pp. 280–281.

Shrewsbury.

		ft.	in.			ft.	in.
1795	February 11	20	3½	1852	February 7	19	2
1770	November 18	19	9½	1852	November 15	18	6
1672	December 23	19	7½	1831	February 10	17	8
1869	December 20	19	4	1849	No date given.....	17	6

NOTE.—There are brass plates in house formerly occupied by Mrs. Davies, Frankwell, Shrewsbury.—Extract Shrewsbury paper.

Evesham.

		ft.	in.			ft.	in.
1848	October 1	14	3	1875	October 21	12	7½
1852	November 11	13	6	1875	July 21	12	0½
1882	October 25	13	0				

Orleton, Tenbury.

1770	Maximum known, probably a few inches above 1795	1836	Nov. 30, 32½ ins. below 1795
1795	Next	1815	39½ ,, ,, ,,
1839	24½ ins. below 1795	1821	Sept. 7, 42½ ,, ,, ,,
1809	31½ ,, ,, ,,	1852	Nov. 13, 13½ ,, ,, ,,

Floods at Tewkesbury

Dyke's *History of Tewkesbury* mentions high floods on the Severn on July 19th, 1587, when a sudden inundation overflowed the meadows to such an extent that the inhabitants were compelled to leave the loaded carts behind them as they went to gather the hay; and so great was the accumulation of hay that "the townsmen were constrained with pitchforks and long poles to

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stand on the bridge of wood to break the cocks, lest the bridge should be carried away by the force of them." In 1610 there was another flood, and again in 1640, when there were no less than eight floods between Midsummer and Michaelmas. This was followed by most severe frost, October 11th to 24th, freezing up all rivers and brooks. On December 23rd, 1672, so great was the flood that the water came into the chancel of the Abbey Church, and was the highest the oldest inhabitant could then recollect. The years 1721 and 1722 were times for floods, and again in 1727, when there were no less than twenty. With respect to 1754, there is an entry as follows:—"In this year there were nineteen sheets of water, which stopped the town mills an hundred days." But in the year 1770 there seems to have been the highest on record. It reached its height on November 17th, for in Bennett's *Register and Magazine* we gather that a Mr. Havard embarked near the turnpike in the High Street by the Bear Inn, and made a voyage round the town, which took him three hours to accomplish. The south side of the chancel of the Abbey was then under water, and Dyke observes that "two houses near the mills were washed down." In 1789 there was another high flood, boats being employed on the long bridge to convey passengers over it. This flood was after the breaking up of a severe frost.

DISCUSSION.

Mr. G. J. SYMONS submitted the following extracts from the Report of the Usk Fishery Commissioners, having reference to floods in that river:—

1872. Floods have damaged passes at Aberbrân and on the Cynrig.

1875. Numerous weirs and passes carried away by the flood of July 14th. The July rain was never heavy, but steady, about ¼ inch per hour—began 9 a.m. on 13th, finished 6 a.m. July 14th, total 5¼ inches.—G. B. Gething.

1876. A violent flood in October carried the river over the fields, and on the water running off left millions of small fish dry on the meadows.

1877. Tremendous flood on November 11th.

Time of highest water.

Brecon	November 11th, 8 p.m.	
Pontygoitre	„	12th, 6.15 a.m.
Trostrey Weir ...	„	12th, 7.50 a.m.

At Brecon 4 inches below 1875.

At Glarmsk above 1875, but 10 inches below a flood on January 24th, 1840.

At the forge mill, near Clytha, the water entered the upper floor, but it was 2 feet 9 inches below the great flood of February 16th, 1795.

At Usk the flood was the greatest for more than 50 years.

Miss E. BROWN, in a letter to the Secretary, gave the following particulars as to the depth of water in a well 100 feet deep at Further Barton, near Cirencester:—

1894—October 26th	10 ft. 4 ins.	
„ November 2nd	37 ft.	
„ „ 9th	37 ft. 5 ins.	
„ „ 16th	52 ft. 1 in.	
„ „ 23rd	40 ft. 11 ins.	
„ „ 30th	30 ft. 6 ins.	

This was exceeded in 1875, when 60 feet was registered on November 15th. No record was kept as far back as 1852; but on September 4th of that year 2·83 ins. of rainfall was measured (in a gauge 9 ins. diameter).

Mr. SYMONS put in a plea for the permanent marking of flood heights, and expressed a hope that any who might have the opportunity would endeavour to carry out this simple but important work.

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PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

November 21st, 1894.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

CAPT. GEORGE WILLIAMS ATKINSON, 5 Manor Park, Lee, S.E.;
JOHN R. EYLES, 80 St. Mary Street, Weymouth;
VALENTINE EDWARD JOHNSON, M.A., South Grove, Alderley Edge;
JAMES LEMON, M.Inst.C.E., Lansdowne House, Southampton; and
JOSEPH MONKHOUSE, Gilcrux, Carlisle,
were balloted for and duly elected Fellows of the Society.

The following papers were read:—

"METHODS OF DETERMINING THE INFLUENCE OF SPRINGS ON THE TEMPERATURE OF A RIVER, AS ILLUSTRATED BY THE THAMES AND ITS TRIBUTARIES." By H. B. GUPPY, M.B. (p. 1.)

"SOME EFFECTS OF THE GALE IN THE HIGHLANDS OF SCOTLAND ON NOVEMBER 17TH AND 18TH, 1893." By ERIC S. BRUCE, M.A., F.R.Met.Soc. (p. 11.)

"HISTORY OF A WATERSPOUT." By ALFRED B. WOLLASTON. (p. 13.)

December 20th, 1894.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

THOMAS WILLIAM ALDWINCKLE, F.R.I.B.A., 1 Victoria Street, S.W.;
CAPT. C. W. ANDREW, The Terrace, Kennington Park, S.E.;
HAMAR BASS, M.P., 145 Piccadilly, W.;
GEORGE GROVE BLACKWELL, Jun., 15 Hillside Road, Wallasey;
WILLIAM NISBET BLAIR, Assoc.M.Inst.C.E., 23 West Hill, Highgate, N.;
HENRY HUGH BRETON, Portswood House, Southampton;
CHARLES BROWNRIDGE, Assoc.M.Inst.C.E., F.G.S., Town Hall, Birkenhead;
JOSEPH STONE BURBERY, Trent House, West Cowes, Isle of Wight;
WILBERFORCE COBBETT, Assoc.M.Inst.C.E., Fareham;
NELSON FREDERICK DENNIS, Assoc.M.Inst.C.E., West Cowes, Isle of Wight;
ERNEST JOHN ELFORD, Hill House Road, Norwich;
E. A. SANDFORD FAWCETT, Assoc.M.Inst.C.E., 1 Victoria Street, S.W.;
MAJOR LAMOROCK FLOWER, 12 Finsbury Circus, E.C.;
CHARLES GILBY, Guildhall, Bath;
ROBERT M. GLOYNE, Assoc.M.Inst.C.E., Town Hall, Eastbourne;
WASHINGTON LYON, 85 Asylum Road, Peckham, S.E.;
THOMAS MANSELL, F.R.M.S., St. Thomas's Hospital, S.E.;
REGINALD EMPSON MIDDLETON, M.Inst.C.E., 17 Victoria Street, S.W.;
GEORGE SHAW, 20 King Edward Street, E.C.;
WILLIAM JOSEPH HOWARD SMITH, Assoc.M.Inst.C.E., Carlisle;
ANDREW SOUTH, Hamilton Road, Ealing, W.;
GEORGE WALTER STEEVES, B.A., M.D., Parkfield Road, Liverpool;
THOMAS DAVID WILLIAMS, F.G.S., Egremont, The Ridge, Hastings;
EDWARD WILLIS, High Street, Eton;
JOHN WILLIS, Stansfield, Windsor; and
ERNEST WORRALL, 5 Beaconsfield Terrace, Seacombe, Liverpool,
were balloted for and duly elected Fellows of the Society.

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MR. R. H. CURTIS and MR. F. GASTER were appointed Auditors of the Society's Accounts.

The following papers were read :—

"REPORT ON THE CLOUD NOMENCLATURE PRESENTED TO THE INTERNATIONAL METEOROLOGICAL COMMITTEE AT UPSALA IN AUGUST 1894." By ROBERT H. SCOTT, M.A., F.R.S. (p. 16.)

"FLOODS IN THE WEST MIDLANDS." By HENRY SOUTHALL, F.R.H.S. (p. 28.)

"METEOROLOGICAL OBSERVATIONS AT MOJANGA, MADAGASCAR, DURING 1892-1894." By S. C. KNOTT. (p. 21.)

CORRESPONDENCE AND NOTES.

Shadows in Fog.—During the fogs of November 1894 I noticed a very remarkable, tall, dark column before one of the gas lamps on Cranleigh Common. On examining the lamp, I found that the flame of the burner was diagonally across the lamp, *i.e.* end on to the corner wires ; and the flame having very little width, the shadow of the wire on the fog was a sharply defined dark column, only to be seen from one particular position. The burners in the other lamps being placed square with the sides of the lamps, the cross lights of the length of the flame prevented any shadow being formed. J. P. MACLEAR.

Mistiness of the Atmosphere in East Winds.—A proof of mist with East winds, although the sky may be apparently clear, appears to be afforded by the following fact :—When printing from a negative exposed to the western sky near the zenith with a West wind blowing, the desired effect was produced in 14 minutes. A few days afterwards the same negative, under exactly the same circumstances, but with an East wind, the sky being apparently as clear as in the first case, took over 20 minutes to print to the same depth. There must have been a haze in the sky inappreciable to the eye. J. P. MACLEAR.

Dry Snow in High Wind.—The gale on the night of January 12th, 1895, presented the features of a little blizzard. The fine snow was blown under the slates and tiles of nearly every roof in Cranleigh village, and found its way into the attics, doing much mischief to ceilings. In many cases, also, the snow was blown through crevices in windows and doors, and formed piles of snow inside. J. P. MACLEAR.

Great Variation of Temperature in 7 hours.—Mr. A. F. Bowker, in writing from Bannack City, Montana, on January 14th, 1895, says : "I have been here in the Rocky Mountains for about two months in the States of Colorado, Utah, and Montana, during which time I have experienced very favourable weather. We have not yet had more than six inches of snow here (6,000 feet above sea level). It is so dry that one does not feel the cold nearly so much as at a very much higher temperature. On December 27th-28th the temperature fell to 40° *below* zero Fahr., and on the following day, only 7 hours after, it was 45° *above*—or a variation of 85° in 7 hours; both are shade readings."

Southerly Busters.—The Hon. Ralph Abercromby, in December 1892, gave to the Royal Society of New South Wales the sum of £100 to promote the study of Australasian Meteorology by offering prizes for essays upon particular phases of weather, and in rewards for special investigations. The subject chosen for the first essay was "The Southerly Burster," the prize being £25. This has been awarded to Mr. Henry A. Hunt, Second Meteorological Assistant at the Sydney Observatory. The essay, which is accompanied by numerous diagrams and illustrations of clouds, has been printed in the *Journal of the Royal Society of New South Wales*, Vol. XXVIII.

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The weather conditions indicating the approach of the burster are described as follows :—

"The climatic conditions preceding a southerly burster are, first, a period of high temperature varying from three hours to three or more days, accompanied in the early part of summer, or towards its close, by wind from the West or North-west, and in the midsummer months generally from the North-east. In the early morning on the day of a 'burst' the sky is white, and hazy of aspect. As the hour of the outbreak approaches, there begin to accumulate in the south ball-shaped, cirro-cumulus or pilot clouds, and frequently, if electric disturbances are to accompany the squalls, heavy cumuli, thunder clouds, rise gradually in the south-west. An hour or so before the squall a heavy cumulus roll appears low down on the southern horizon. The interval between this appearance and the beginning of the gusts depends entirely on the velocity of the wind. Afar off this cloud roll appears most frequently due south, but sometimes south-south-west, or even south-west. It is sharply defined, dark on the edges, with lighter shades towards the centre. The roll is from 30 to 60 miles in length. Sometimes it appears singly ; on other occasions there are a multitude of these formations heaped one above the other, with light cirrus below. Generally, if the burst is of the first order, it is followed by an overcast sky composed of nimbus, from which patchy rain descends.

"As the cloud roll approaches, it gradually loses its symmetrical aspect, and careful observation reveals a light cirrus fringe rising from underneath it in front, falling over the top, and trailing behind the advancing cloud. Up to this time the wind has been blowing with steadily increasing force from a Northerly direction, but at this stage it drops suddenly, and a profound calm prevails, broken only at intervals by a few fitful puffs. This state of things lasts for a varying space. If the southerly arrives during the heat of the day, it endures but a very short time ; if at night, the calm is of no longer duration.

"Meanwhile the cloud roll is seen rapidly approaching, clouds of dust rise in the southern part of the city four miles away, and gather volume as they come, until they almost hide the city as viewed from Observatory Hill, while from immediately under the roll light clouds rush forward with great velocity, only to be thrown back over the top of it as they reach the front ; the wind vane on the time ball tower flies to the South, and the wind reaches us on the ground a moment later, and in a few moments is blowing with the force of a gale."

The author deals with the burster in other colonies, and shows that it is intensified in New South Wales by geographical features, and that it is sometimes caused by monsoonal depressions. Bursters always result in a fall of temperature, the average fall being 18°·1. The greatest diminution of temperature takes place during the first hour, and the fall is most sudden when the burst comes at midday. The greatest fall on record was that registered on December 30th, 1891 : at 1.50 p.m. the temperature was 97°·5 ; at 1.55, after the change to south, it had fallen to 80°·3; and at 1.57 to 79°·7 ; and at 2.15 it had descended to 75°·0, being a fall of 22°·5 in 25 minutes.

Mr. Hunt traces different kinds of bursters, their rate of progress along the sea coast, and relation to general weather conditions. He also gives a detailed description of two bursters, with diagrams of weather before and after, and photographs of clouds, with full notes of cloud changes. From the records of the past 31 years it appears that the average number of bursters in each year is 32, the greatest being 66 in 1869, and the least 16 in 1890.

Cyclonic Precipitation in New England.—Some six years ago Prof. Winslow Upton examined the reports of the observers of the New England Meteorological Society for the 19 months, January 1885 to July 1886, with the view of investigating the distribution of precipitation in cyclones. He has recently continued the discussion from August 1886 to December 1892, and finds that the results confirm his previous conclusions. The most important results are :—

1. The precipitation is sometimes along the path of the cyclone, but in the majority of cases the greatest amount is found many miles away from the path. These maximum areas are at the right or left, or on both sides of the path. The situation of the observing stations is more favourable to showing the maximum areas at the right of the paths of storms which come to New England from the west, and at the left of those which come from the south ; hence these pre-

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dominate in the cases examined. There is a larger proportion of cases in which the greatest precipitation lies along the track in southern than in western cyclones, and the distances are less in the former class when the maximum area is displaced.

2. The precipitation area does not maintain a constant position with regard to barometric centre of the storm, while the storm is in transit over New England. While departures from regularity are evidently to be expected in the curve of the rain front and rear as the precipitation area passes over country of varied topography, there seems to be a marked agreement between both rain front and rear in showing a different average rate of progression across New England than that of the barometric centre. In a few cases the rate of the rain front and rear is more rapid than that of the centre, but in the great majority of storms examined the rate was very much less. In other words, the barometric centre is usually displaced forward in the precipitation area while the cyclone is crossing New England.

Aberrations of Audibility of Fog Signals.—The U.S. Hydrographic Office in the *Pilot Chart* for November 1894 directs attention to the uncertainty of audibility of fog signals, and quotes the following examples furnished by Mr. A. B. Johnson of the U.S. Lighthouse Board.

The idea that sound is always heard in all directions from its source according to its intensity and force, and according to the distance of the hearer from it, is an erroneous popular notion. Instances of this fallacy have accumulated, and they are emphasised by shipwrecks caused by the insistance of mariners on the infallibility of their ears, who have accepted unquestioned the guidance of fog signals as they do that of lighthouses during clear weather. Audition is subject to aberrations, and under circumstances where little expected. Implicit reliance on sound signals often leads to danger if not death.

The steamer *Rhode Island* was wrecked in a fog on Bonnet Point, R.I., November 6th, 1880. Investigation showed that Beaver Tail Point fog signal (about 2 miles distant) was in full operation, and also proved that while there was no lack in the volume of sound emitted, there was often a decided lack in the audition of that sound. It could not be heard at the intensity expected, nor at the place expected; it would be heard faintly where it ought to be heard loudly, and *vice versâ*; it could not be heard at some points, while it could be heard further away; it could be heard and lost, and heard and lost again, all within reasonable earshot, and all this while the signal was in full blast and sounding continuously.

On the night of May 12th, 1881, the *Galatea* grounded in a dead calm and dense fog on Little Gull Island, Long Island Sound, about one-eighth of a mile from the fog signal. Investigation by the officers of the Lighthouse Board proved that the fog signal was in operation, it having been heard 15 miles distant at Mystic, Conn. Several days were spent steaming about Little Gull Island, and the aberrations in audition here were as numerous and eccentric as at Beaver Tail.

Gen. Daune, U.S. army, in a report to the Lighthouse Board, states, regarding the action of six steam fog signals on the coast of Maine, that they have frequently been heard 20 miles distant, and again not heard at a distance of 2 miles. The whistle at Cape Elizabeth was heard at Portland, 9 miles away to windward, during a heavy North-east snow storm, the wind blowing a gale at the time. The greatest difficulty observed, he says, arises from the fact that the signal appears to be surrounded by a belt varying in radius from 1 to 1½ miles, from which the sound appears to be entirely absent. This action is common to all ear signals, and has been observed at all stations, even one on a rock 20 miles from the mainland, with no surrounding objects to deflect the sound.

After carefully considering all publications and experiments on the subject, Mr. A. B. Johnson makes the following recommendations:—

"When approaching from windward, fog signals are likely to be heard earliest from aloft; from leeward on deck. Do not assume that you are out of hearing distance if the signal is not heard; nor that it is at a great distance because it is faint; nor near because it is plainly heard; nor that a given point of the course is reached because the signal is or is not heard with the same intensity as on some former occasion; nor that the signal has ceased sounding because it is

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not heard within easy ear-shot; nor that the aberrations of audibility are the same in different fog signals. Do not expect to hear the signals so well when the upper and lower air currents are moving in opposite directions; or when wind and tide are contrary; or during electrical disturbances; or when the sounds must come over an island or point of land. When a bluff exists behind the signal, be prepared for irregular intervals in audition, such as would follow were the sound to ricochet as a cannon ball. Thus, you might hear it at 2, 4, 6, 8, etc., miles, and lose it at 1, 3, 5, 7, etc., miles, or at any other combination of distances, regular or irregular. When expected signals are not made, keep the lead going freely and proceed carefully."

Climate of Corsica.—Mr. R. Richardson, in the *Scottish Geographical Magazine* for October 1894, gives some particulars about the climate of Corsica. After referring to a pamphlet published by Mons. C. Guérin, formerly a meteorological observer at Ajacco, he says: M. Guérin makes the somewhat remarkable statement that, after numerous observations in years which were reported rainy, only 50 days on an average per annum were recorded at Ajaccio during which the sun did not shine. He adds that most rain falls during the autumnal equinox towards the close of September, less rain falling during the vernal equinox. As to winds, the worst are the Libeccio (South-west) and the Mistral (North-west), whilst the East wind and South-east wind (Sirocco) are extremely hot. M. Guérin declares, after a long experience, that there are really only two seasons at Ajaccio, one warm and dry, from May to September; the other genial and temperate, from October to the end of April. The temperature in winter is more constant than on the Riviera, where the icy wind from the Alps makes more victims than is generally supposed. Again, the air of Ajaccio is more salubrious for invalids than that of Algiers, where the summer is scorching, and winter, owing to the vicinity of the Atlas range, more trying than in some towns in the centre of France.

The fact is that we must remember, in comparing Corsica with the Riviera or Algeria, that Corsica is an island, and therefore much more exposed than they are to marine influences. Whilst these marine influences temper heat, they also prevent cold winds from having their icy character which a passage in winter over land alone is apt to entail.

The average temperature and rainfall at Ajaccio are as follows:—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Temp.... ...	51°·0	51°·3	52°·5	58°·1	65°·3	70°·8	75°·3	77°·2	71°·8	63°·6	56°·8	51°·8	62°·0
Rain	2·39	1·69	1·94	2·07	1·55	0·72	0·15	1·07	1·01	2·81	4·96	2·40	22·76

The climate of Corsica, as a rule, is healthy, except on the east coast and near marshes at the mouths of rivers. To overcome the malarial atmosphere at such places, eucalyptus trees have been planted along the roads traversing them. Both Dr. Bennet and Miss Gertrude Forde agree that the best time to visit Corsica is during spring. "The climate," says the latter, "is delicious in early spring, and the flowers and trees are in their glory in April and May. The low-land towns become hot and unhealthy for visitors in June, if not before. The east coast of the island is to be avoided by travellers, being rife with malarious fever."

Temperature of the Earth's Crust in the Sahara.—Mons. Georges Rolland has made a communication to the Académie des Sciences on the rise of temperature with the depth, as ascertained by observations in artesian wells, mines, &c. About 1° F. for every 53 feet is the usual increase of temperature below the level of constant temperature, but in the Sahara the rise is much more rapid. In the Wed Rir the temperature of the subterranean reservoirs has been found to be from 73°·4 to 80°·2, and the mean of the most reliable observations along the principal artery is 78° for an average depth of 246 feet. It may be estimated, according to MM. E. Renou and L. Teisserenc de Bort, that the stratum of constant temperature lies at a depth of about 65 feet, and that its temperature is 71° to 78°. Thus the difference of level between the stratum of no variation and the great reservoir of the Wed Rir would be about 180 feet, and the difference of temperature 6°, and consequently the rate of increase about one degree for every 30 feet. Further south, at Wargla, M. Rolland's observations indicated a

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yet more rapid rise. It is true that these observations apply only to the water in the wells, but M. Rolland believes that, under the actual conditions, the temperature of the wells of the Sahara may be taken to be that of the surrounding strata. In conclusion, M. Rolland affirms that in many parts of the Sahara, between lat. 33° and 35°, the temperature of the ground really rises with the depth in the ratio of not less than one degree to 35 feet, and often more rapidly; but he does not consider that so high a variation of temperature inversely to the latitude can be inferred, as a comparison with observations in Europe would give. —*Scottish Geographical Magazine.*

RECENT PUBLICATIONS.

American Meteorological Journal. October-December 1894. Vol. XI. Nos. 6-9. 8vo.

The principal articles are :—The Meteorological Services of South America II.: by A L. Rotch (10 pp.). In this paper the author gives an account of the meteorological organisations in the Argentine Republic; Uruguay and Brazil.—The forecasting of Ocean Storms, and the best methods of making such forecasts available to commerce : by W. Allingham (10 pp.). This is the reprint of a paper read at the International Meteorological Congress at Chicago in August 1894.—Sunspots and Auroras : by Prof. H. A. Hazen (7 pp.).—Cyclonic Precipitation in New England : by Prof. W. Upton (30 pp.).—The barometer at Sea : by T. S. O'Leary (8 pp.).—Psychrometer Studies : by Dr. N. Ekholm (8 pp.).—Meteorological records obtained in the upper air by means of kites : by H. H. Clayton (6 pp.). This paper describes some experiments and observations made by Mr. W. A. Eddy by means of kites at the Blue Hill Observatory. Among other interesting results were the following :—On July 31st, 1894, the kites were let up at noon in a sea breeze. When the kites had risen about 40) feet above the hill the topmost kite veered around from the west, thus giving the depth of the sea breeze as 1,000 feet above sea level. During the afternoon the sea breeze steadily increased in depth, and veered towards the south. On August 6th, during the prevalence of light winds from the West, an effort was being made to elevate the kites, which refused to remain permanently in the air, since the air movement was not sufficient to sustain the heavy kites employed. But at 2.20 p.m., while a 5 foot kite was being maintained at a short distance above the hill by means of sundry jerks and pulls, a rather large cumulus cloud approached the zenith, and suddenly the kite began to ascend almost vertically. Cord was rapidly let out, and in a short time the kite was flying directly overhead, and continued to rise until all the available cord had been let out. It followed the cumulus for a short distance beyond the zenith, then rapidly dropped to the earth. Mr. Eddy afterwards measured the length of cord out and reported 1,172 feet, which must have been approximately the altitude of the kite, since the cord hung almost vertically under it. This seems to furnish striking evidence of the existence of ascending currents under the cumulus clouds. The kites also at times gave evidence of great aerial eddies around and above the hill, which swayed the kites from side to side.—Meeting of the International Meteorological Committee : by A. L. Rotch (7 pp.). This is an account of the proceedings at the Meetings of the Committee held at Upsala, August 20th to 24th, 1894.

Annuaire de la Société Météorologique de France. April-September 1894. 4to.

The principal papers are :—Sur l'origine des orages et des perturbations atmosphériques : par J. R. Plumandon (7 pp.).—Recherches pratiques sur la photographie des nuages : par G. Raymond (7 pp.).—Influence réelle des eaux sur la température : par M. Bouvet (4 pp.)—Sur le régime des pluies dans le Canal de Suez : par A. Angot (4 pp.). The author has tabulated the rainfall at Port Saïd, Ismailia, and Suez, the records extending over 17 years, viz. 1866-68 and 1880-93. The mean monthly results are :—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Port Said... ...	·88	·47	·39	·27	·03	·01	—	—	·03	·27	·24	1·03	3·62
Ismailia	·47	·33	·29	·15	·16	—	—	—	—	·17	·06	·40	2·05
Suez	·24	·09	·08	·16	·21	·01	—	—	·01	·03	·07	·12	1·02

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Prévisions sur la tenue des sources et des eaux courantes dans le bassin de la Seine pendant l'été et l'automne 1894 : par G. Lémoine (2 pp.).—Résumé des observations météorologiques faites à l'Observatoire de la Tour Saint-Jacques en 1891, 1892, et 1893 : par J. Jaubert (22 pp.).—Trombe dans le Calvados, 6 Juin 1894 : par G. Guilbert (2 pp.).—Observations météorologiques faites au cours d'une mission dans le pays des Touareg Azdjer, Octobre 1893-Mars 1894 : pars F. Foureau (10 pp.).

Cloudland ; a Study on the Structure and Characters of Clouds. By Rev. W. Clement Ley, M.A., F.R.Met.Soc. 1894. 8vo. 208 pp. and 6 plates.

This work has been very well got up, and is illustrated with numerous coloured plates, photographs, charts, and diagrams. The author has been a life-long observer of clouds, and he here sets forth the results of his experience and proposes a new classification and nomenclature of clouds. The list comprises 27 separate forms, which are arranged as follows :—

Clouds of Radiation.

Nebula—Fog. *Nebula Stillans*—Wet Fog. *Nebula Pulvera*—Dust Fog.

Clouds of Interfret.

Nubes Informis—Scud.
Stratus Quietus—Quiet Cloud.
Stratus Lenticularis—Lenticular Cloud.
Stratus Maculosus—Mackerel Cloud.
Stratus Castellatus—Turret Cloud.
Stratus Præcipitans—Plane Shower.

Clouds of Inversion.

Cumulo-rudimentum—Rudiment.
Cumulus—Heap Cloud.
Cumulo-stratus—Anvil Cloud.
Cumulo-stratus Mammatus—Tubercled Anvil Cloud.
Cumulo-nimbus—Shower Cloud.
Cumulo-nimbus Grandineus—Hail Shower.
Cumulo-nimbus Nivosus—Snow Shower.
Cumulo nimbus Mammatus—Festooned Shower Cloud.
Nimbus—Rainfall Cloud.
Nimbus Grandineus—Hail-fall.
Nimbus Nivosus—Snow-fall.

Clouds of Inclination.

Nubes Fulgens—Luminous Cloud.
Cirrus—Curl Cloud.
Cirro filum—Gossamer Cloud.
Cirro-velum—Veil Cloud.
Cirro-velum Mammatum—Draped Veil Cloud.
Cirro-macula—Speckle Cloud.

The author describes each of the above forms, and gives an account of their formation.

As observations of the direction of *Cirrus* are held to be of service for forecasting purposes, the following rules by the author may be considered useful and instructive :—

"*Cirrus* moving from North or North-east with a high barometer is a sign of settled weather in summer and of temporarily fine weather in winter. With a low barometer it is a sign of marked improvement in weather.

"*Cirrus* moving from East, a rare occurrence, is a sign of fine weather in winter, but of unsettled weather in summer.

"*Cirrus* moving from South-east (but it rarely does so with a low and unsteady barometer) is a sign of improving weather in winter, and in summer frequently indicates coming thunderstorms.

"*Cirrus* moving from South is generally an indication of unsettled weather, especially in summer. The temperature is then usually above the mean for the time of year.

"*Cirrus* from South-west indicates unsettled and sometimes stormy weather in winter. In summer it often precedes thunderstorms, but with a high barometric pressure and a high temperature it frequently has no disturbing influence, and is then usually replaced by *Cirro macula*.

"*Cirrus* from West is commonly in summer a symptom of fair weather, but it is less so in winter.

"*Cirrus* from North-west, when not tending to the form *Cirro filum*, is an indication of temporary fine weather, especially in summer."

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Mr. Ley also devotes chapters to the theory of atmospheric currents; the prevailing winds of the globe; cyclones and anticyclones and their cloud-forms; and prevalent cloud-forms of the globe.

In conclusion, the author urges the preparation of a set of typical weather charts for each distribution of elements, showing isobars, winds, and weather, including cloud-forms and upper currents. Each chart should be numbered and printed on the left page of a large book, and on the opposite page a short description of probabilities of general changes should be given in reference, more especially, to the season of the year. If these charts were plentifully distributed over the country, at sea ports, &c., all that the central office need do would be to wire simply the number of the page, when any one who turns to the chart indicated would know at once what weather to expect.

Meteorologische Zeitschrift. Redigirt von Dr. J. HANN und Dr. G. HELLMANN. October and November 1894. 4to.

The principal contents are:—Einige Ergebnisse wissenschaftlicher Fahrten des Münchener Vereines für Luftschiffahrt: von S. Finsterwalder und L. Sohncke (16 pp.). These ascents are particularly interesting, from the proximity of Munich to the mountains, where there are several high level stations. The result of all the temperature observations is to show that in the free atmosphere, as compared with mountain stations, the temperature is lower by day and higher by night, so that the range at the mountain stations is greater than in the balloon. The next point investigated was the evidence of unstable equilibrium preceding thunderstorms. Of this, five cases came under observation. The other subjects discussed are the inversion of temperature on warm nights in summer; the decrease in aqueous vapour with height; and the development of stratification in the atmosphere. On the whole, the results agree very satisfactorily with the theoretical deductions of Dr. Hann.—Einige Bemerkungen über die Anwendung der Photogrammeter zur Messung von Wolkenhöhen: von N. Ekholm (5 pp.). This is a correction of some statements contained in a pamphlet by Dr. Åkerblom, issued at Upsala last summer.—The November number is entirely occupied by three papers by Dr. A. Woeikof, at least as far as the printing in large type extends. The first paper is on the dependence of rain upon changes in the sectional area of air currents. The author seeks to prove that the stronger the winds the less rain falls. The second paper is on the daily range of temperature and hydrometeors in Northern India. He finds that there are three types as regards relative humidity, viz.—1. Minimum at sunrise, and maximum in afternoon or evening. 2. Double period: two maxima in the late morning and evening, and two minima in the early morning and the afternoon. 3. Maximum in the morning and minimum in the afternoon. He gives the stations coming under each class, and proceeds to explain the causes of the difference. The third paper is on the rainfall of the south-west of the Caucasus.

Meteorology, Practical and Applied. By JOHN WILLIAM MOORE, B.A., M.D. Sanitary Series, No. 1. 1895. 8vo. 445 pp.

This book is divided into four parts. The introduction is followed by an account of the methods which are employed in practical meteorology. A large portion of this, however, 68 pages in all, is devoted to the history, work, and publications of the U.S. Weather Bureau. The third part treats of climate and weather. In the fourth part some of the practical bearings of the subject are pointed out. The author also discusses the question of the influence of weather and season upon disease. The work is copiously illustrated with engravings of instruments, &c.

Proceedings of the Australasian Association for the Advancement of Science. 1894. 8vo.

Among the papers read before the Association was "Meteorological Work in Australia: a Review," by Sir C. Todd, F.R.S., which gives a brief and succinct account of meteorological work in Australia. Sir C. Todd traces the history of the meteorological organisations in New South Wales, Victoria, South Australia, Western Australia, Queensland, Tasmania, and New Zealand; and also describes the present condition of meteorological science. With regard to South Australia, the three principal weather conditions are:—1. A continual series of

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anticyclonic areas, which in the winter pass over the interior, covering the whole or greater part of the continent, with gradual falling gradients from the centre, while in the summer they pass along or near the south coast. 2. Cyclones, disturbers of the peace, but bringing fruitful rains; sometimes, alas! disastrous floods. These are mostly of tropical origin, and, starting on a west to south-west course, they re-curve south of the trade belt, and move to the south-east. Some—those approaching from the north-east of Australia—strike the east coast of Queensland, others enter by the Gulf of Carpentaria, and passing inland, shed rains over the western interior of Queensland and New South Wales; others pass over the interior from the north-west; whilst others again pass to the west of Australia, and ultimately, rounding the Leeuwin, appear as a south coastal disturbance. 3. Northerly extensions of the antarctic low pressure, which passing along the south coast, give winter rains, and, on their retreating side, south-westerly gales.

Report on Meteorological Observations in British East Africa for 1893. By E. G. RAVENSTEIN, F.R.Met.Soc. 1894. 8vo. 12 pp.

This Report, which is published by authority of the Directors of the Imperial British East Africa Company, gives a summary of the meteorological records kept at Chuyu, Mombasa, Malindi, Magarini, Lamu, Witu, and Kisimayu, on or near the coast, and at Machakos and Fort Smith in Kikuyu in the interior. The rainfall appears to decrease very rapidly northward along the coast. Mr. Ravenstein believes that the mean annual rainfall is as follows:—Mombasa, 51 ins.; Malindi and Jilori, 45 ins.; Magarini, 39 ins.; Lamu, 37 ins.; and Kisimayu, 11 ins.

Symons's Monthly Meteorological Magazine. October-December 1894. Vol. XXIX. Nos. 345-347. 8vo.

The principal articles are:—Protection from Lightning (2 pp.).—The recent Drought in the Midlands: by Rev. G. T. Ryves and Rev. T. A. Preston (5 pp.).—Enormous Hailstones (3 pp.). On August 26th, 1894, a number of violent thunderstorms occurred in the north of France and in Belgium, and were accompanied by hail of great size. It is reported that many of the hailstones weighed 7 oz. At Blancfosse, Oise, some of the hailstones weighed 10½ oz.; at Beaucourt hailstones were picked up weighing nearly 2 lbs.; while at Mézières one which came through a window and broke a workbox is stated to have weighed 2 lbs. 10 oz.! Sheep, birds and game were killed by the hailstones.—Rainfall at Jerusalem (4 pp.). From observations extending over the 32 years, 1861-1892, it appears that the average monthly rainfall at Jerusalem is as follows:—

	Rain. in.	No. of Days.		Rain. in.	No. of Days.
January ...	6·38	12	July ...	·00	0
February ...	5·06	10	August ...	·00	0
March ...	3·56	8	September ...	·04	0
April ...	1·71	5	October ...	·41	2
May ...	·27	2	November ...	2·29	6
June ...	·01	0	December ...	5·50	10

The yearly total is 25·23 in., with 55 rainy days.

The mean rainfall is almost identical in total with that in London, but no rain falls between May and October, and about a fifth of the yearly total falls in each of the three months, December, January, and February.—Storm of September 20th, 1894, at Martinique (2 pp.).—The Floods of November 1894 (10 pp.).

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Separate copies of Papers appearing in the *Quarterly Journal* are kept on sale, at the Office of the Society, at a price of Sixpence per Half Sheet, or portion thereof. The following are some of those on sale:—

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Royal Meteorological Society.

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SESSION 1894-5.

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November	21, 1894	March	20, 1895
December	19 ,,	April	17 ,,
January	16, 1895	May	15 ,,
February	20 ,,	June	19 ,,

ANNUAL GENERAL MEETING,

January 16, 1895.

The Meetings from November to March will be held at the Institution of Civil Engineers, 25 Great George Street; and those in April, May, and June at the Surveyors' Institution, 12 Great George Street, S.W.

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QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY.

VOL. XXI. APRIL 1895. No. 94.

WEATHER FALLACIES.

An Address delivered to the Royal Meteorological Society, January 16th, 1895.

BY RICHARD INWARDS, F.R.A.S.,

PRESIDENT.

IN the long and patient pursuit which the attainment of all accurate knowledge exacts from man, it may sometimes be instructive to turn one's gaze backward and contemplate the errors which have been corrected, the fallacies which have been demolished, and the superstitions which have been lived down; and this consideration has prompted me to take for the subject of this year's Address that wide range of human opinions which may fitly be classed under the head of "Weather Fallacies."

Nothing could have been more in accordance with the law of growth in other branches of knowledge than that Meteorology should, in its earliest dawn, have been with difficulty able to emerge from the mists and darkness of guesses and surmises such as have surrounded the transfer of any truth from the barbaric to the philosophic stage,

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It is to the Greeks that we must look for the first real weather observations after the matter had passed through what may be called the mere savage phase; and we find Hesiod, Theophrastus, and Aratus presenting us with an early code of rules, which serve at least to show us how little we have ourselves advanced in some matters since their time.

One of our Fellows, Mr. J. G. Wood, has just given to the world an excellent and scholarly translation of the work of Theophrastus, which has not previously been put in an English garb, and Mr. Wood has done the whole country a great service in giving us this translation of the *Winds and Weather Signs*, a book which contains a host of rules and observations about the weather, and which, as might have been expected from the production of the favourite pupil of Plato and Aristotle, is singularly free from errors of the grosser and more superstitious kind, such as were plentifully produced in Western Europe many centuries later.

But long before the time of Theophrastus, and probably very soon after the invention of agriculture itself, there were weather gods and weather fallacies; for we find that Jupiter Tonans and Pluvius—the thunderer and the rain maker—were set by men on the highest pedestals. And centuries after this, Lucian tells us that it was usual in his time to offer prayers for suitable weather, and he recounts in his *Dialogues* how two countrymen were at the same time offering up contrary petitions,—one that not a drop of rain might fall until he had completed his harvest, while the other prayed for immediate rain, in order to bring on his backward crop of cabbages,—both suppliants only too sure to find that the ears of the image were deaf as the stone of which they were made, and that the wheels of the universe would not wander or turn back for any selfish ends of man.

In considering these early times when the weather had to be studied from cloud, sky and sea, and from the behaviour of the animals and plants, we must be ready to excuse men for doing that which is still too frequently a cause of error, viz. foretelling what they most wished for, and putting down as universal law that which was only a coincidence of totally independent events. In considering weather fallacies it will be impossible to follow a chronological order, so I shall treat them, or rather a small portion of them, under the heads of saints' day fallacies, sun and moon fallacies, and those concerning animals and plants, while finally I shall consider the almanack makers, weather prophets and impostors who have from time to time furnished the world with materials for its credulity or its ridicule.

The first class of weather fallacies which I shall scarcely more than mention, are those which refer to the supposed connection between the weather of any day in the week or year, and that of any other period, and it may be as well to state at the outset that there is no kind of foundation in fact for any of these so-called rules. They are for the most part born of the wish to see certain kinds of weather at certain times of year, and, like all these predictions, were faithfully remembered when they came true, and promptly forgotten when they failed. One has often heard—

"Fine on Friday, fine on Sunday,"

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Or that "Friday is the best and worst day of the week," and the superstition even extends to hours of the day, for we have—

"Rain at seven, fine at eleven,"

which is only another way of saying that rain does not usually last four hours, and the rule generally fails when applied to daily experience, but the host of proverbs connected with saints' days are more difficult to deal with, on account of the longer time which elapses between the prophecy and its fulfilment or failure. All or most of these proverbs concern the days of certain saints, though I think no one imagines that this is anything more than a convenient method of fixing the date, because our ancestors had a saint for every day, so that they naturally referred to the day by his name.

There are forty weather saints, among the most prominent of whom is undoubtedly St. Swithin, whose day is July 15th, and the superstition is that if it should rain on that day it will rain for 40 days after. Now, as Mr. Scott observes, this date is very near a well known bad time in wet years, as the terms, long in use, of "St. Margaret's flood" and "Lammas flood" abundantly testify. The fact that some of these heavy rains began on July 15th has been enough material for the adage-monger, and so we have another "universal" law laid down, a law which is, however, constantly broken, as every student of the weather very well knows. The whole thing is a fallacy of the most vulgar kind, and ought speedily to be forgotten, together with all the adages which make the weather of any period depend on that of a distant day.

Turning in weariness from this class of superstitions, which may be said to belong to the self-exploding order, we are next met by an extensive array of authorities who, under the protecting shield of astronomy, profess to have framed infallible rules for the weather as judged from the ever-varying relative positions of the sun, moon, and planets. They attack us systematically and persistently, appealing to analogy, to reason, and to common sense. But it is sometimes necessary to be on our guard, even against common sense, in considering problems to which uncommon sense has for centuries been devoted without avail. The well-known action of the sun and moon upon the ocean tides is generally the starting point of these theorists, and it is soon shown to common sense that when the earth is nearer the sun, or the moon is nearer to the earth (it being remembered that they move in elliptic orbits), or when both sun and moon are, as it were, pulling together, as at new moon, there ought to be a tide of atmosphere caused by their influence similar to the tides of the ocean, which such agencies undoubtedly produce. But we find that whatever so-called reason, analogy, and common sense may seem to dictate, the facts will not follow in the path marked out for them; and the atmospheric tides refuse to ebb and flow, except in a most infinitesimal degree, quite disproportioned to their supposed moving forces. The theorists must try again, and they do so by pointing out that the moon and earth move in planes which are inclined to each other at an angle, and that at some times of the year the attraction of the sun and

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moon are acting in somewhat widely diverging lines, whilst at others they are pulling more nearly in the same plane. Here is, they say, a clear case. At times, when the angle is greatest, there should at any rate be worse weather caused by the conflicting forces. When the moon is said to be "on her back," or, in other words, when the line of the shadow boundary of the half-moon or crescent is much inclined to the earth's axis, then is the time, say they, for tempests and commotions to come. But again the spirits from the "vasty deep" do *not* come when called, and we have to invent other causes for our earthly disturbances.

It may be safely said that a new moon theory as to the weather comes out at least once a year, and it has been attempted to connect the honoured name of Sir William Herschel with a table which professed to show the dependence of weather changes on those of the moon.

By the kindness of Mr. Symons I am able to show you on the screen a much magnified representation of this production, now very scarce, and which has the name of Herschel in large capitals, no doubt as a sort of ballast to give it weight and steadiness, though it does not definitely state that Herschel had anything to do with it. Herschel's own letter on the subject runs as follows :—

Sir

I am glad of an opportunity to say that prognostications of the weather are so much above the knowledge of astronomers that I have taken uncommon pains publicly to contradict reports of predictions that have been ascribed to me. You may therefore be assured that what you have heard as my opinion about the frost is without the smallest foundation. If at any time Slough should be in your road, I shall be very glad to see you here, and remain

Sir

your most obed^t
Serv^t

Wm Herschel

Slough
near Windsor
Feb 6. 1814.

So that any Fellow of this Society who sees one of these diagrams in the future will know that it is a fraud.

Of course it is in the power of every one to check the predictions which are so often issued with respect to the changes of the weather taking place at the change of the moon; but many eminent men have occupied them-

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selves with the subject, and the result is that no correspondence between the two classes of phenomena has been established.

Dr. Horsley examined the weather tables of 1774, as published by the Royal Society, and out of 46 changes of weather in that year only 10 occurred on the days of lunar influence, only two of them being at the new moon, and none at all at the full. M. Flarguergues, of Viviers, found also as the result of 20 years' observations, that the barometer readings taken when the moon was furthest from the earth averaged 755 millimetres, and when nearest, 754 millimetres, showing a difference of 1 millimetre or about ·04 inch, and this in a direction against the theory, the pressure being greater by that amount when the moon was farthest from the earth.

Various other weather seers have pinned their faith on lunar cycles, and have predicted that weather changes would repeat themselves, as soon as the sun and moon got back into the same relative positions, which they do in 19 years, with only an error of an hour and a half. Others, such as Mr. G. Mackenzie, advocated a cycle of 54 years, but it may be summarily stated that all the cycles have broken down, and that, as far as we know, there is no definite period after which the weather changes repeat themselves.

Other fallacies about the moon are numerous, such as that the full moon clears away the clouds; that you should only sow beans or cut down trees in the wane of the moon; that it is a bad sign if she changes on a Saturday or Sunday; that two full moons in a month will cause a flood; that to see the old moon in the arms of the new brings on rain, and many others, of which a catalogue alone would take up a good deal of space. M. Flammarion says that "the moon's influence on the weather is negligible. The heat reaching us from the moon would only affect our temperature by 12 millionths of a degree; and the atmospheric tides caused by the moon would only affect the barometric pressure a few hundredths of an inch—a quantity far less than the changes which are always taking place from other causes." On the whole we are disposed to agree with the rhyme which thus sums up the subject:

> The moon and the weather
> May change together;
> But change of the moon
> Does not change the weather.

Even the halo round the moon has been discredited, for Mr. Lowe found that it was as often followed by fine weather as by rain, and Messrs. Marriott and Abercromby found that the lunar halo immediately preceded rain in 34 cases out of 61. We always have a lingering hope that some future meteorologist will disentangle the overlapping influences, and arrive some day at a definite proof that our satellite after all has something to do with our weather.

About the sun, also, there are many fallacies, and ever since the discovery that the spots which appear on his surface have a period of greatest and least frequency, there have been theorists in shoals who have sought to prove that this fact rules our weather. It has undoubtedly been found that the

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frequency of sun spots and the variations of the magnetic needle are intimately connected; and it is almost equally well established that the aurora appears and disappears in some sort of sympathy with the sun spot variations. But this, up to the present, is as far as we can get in this direction, for our weather seems to have no relation whatever to these changes.

The more recent discoveries of prominences visible round the disc of the sun during an eclipse, and of the light clouds only seen in M. Deslandres' spectro-photographs, will no doubt call out new weather theories on the subject. And I must confess to a wish that those mysterious flame-like bodies rushing from the sun millions of miles into space, will be found to have some influence on the upper layers of our earth's atmosphere; but I also hope that we may be saved from a theory on the subject until more facts are before us.

Coming down to earth again, we are met by a long array of fallacies connected with the behaviour of animals and plants, and which have a supposed connection with weather changes. Few of these are so well grounded that they may be considered as proved, and as nothing is sacred to a meteorologist, our veteran Fellow, Mr. E. J. Lowe, F.R.S., has endeavoured to put some of the rules from this source to the test of definite observation. He took a number of well known signs said to indicate change, and carefully noted what happened after each sign, and although he does not say that all indications from animals, birds and plants are useless, yet certainly those he did investigate seemed utterly to break down.

He took the well-known signs of bats flying about in the evening, many toads appearing at sunset, many snails about, fish rising much in lake, bees busy, many locusts, cattle restless, landrails clamorous, flies and gnats troublesome, many insects, crows congregating and clamorous, spider-webs thickly woven on the grass, spiders hanging on their webs in the evening, and ducks and geese making more than usual noise. Mr. Lowe found that in 361 observations of the above signs, they were followed 213 times by fine, and only 148 times by wet weather; so that even after the prognostications for rain, there was a greater preponderance of fine weather. He called a day fine when no rain was measurable in the rain gauge. Mr. Lowe says that even swallows flying low cannot be depended on, as, especially at the close of summer and autumn, they almost invariably skim the surface of the ground, and Mr. Charles Waterton, the naturalist, decided, after careful observation, that the unusual clamour of rooks forms no trustworthy sign of rain. These must, therefore, swell the list of fallacies, although there are many other rules which have not been so carefully examined, but which may still be true. My own impression is that although it is painful to dismiss the animals from their ancient position as weather prophets, we may consider them as indicating what they feel, rather than as predicting what is to come, and that their actions before rain simply rise from the dampness, darkness or chilliness preceding wet weather, and which render these creatures uneasy, but not more so than they affect man himself. The sheep turning its back to the wind (one of the best known signs of rain) is probably only

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that it may shelter its least protected part from the effects of the weather; and many of you must have observed sheep sheltering their heads from the heat by getting them into the shade of each other's bodies in a similar way.

As to cows scratching their ears, and goats uttering cries, and many other signs of bad weather, they are at least very doubtful; whilst the adage about the pig which credits him with seeing the wind, carries with it its own condemnation.

The medicinal leech is still left on the list of weather prophets, though he has no doubt had his powers exaggerated; and two books have been written about his behaviour during changes of weather. One is by Mrs. Woollams, who, during a long illness, watched a leech in a bottle, and carefully noted what it did; and the other is by a gentleman at Whitby, who came to the conclusion that the leeches could be made to give audible and useful storm warnings. So he contrived the instrument, of which I now show you a drawing taken from his book. No one would imagine from its appearance what its use could be. It consisted of 12 glass bottles each containing a leech in water, and so arranged in a circle, in order, as the humane inventor states, that the leeches may see each other and not endure the affliction of quite solitary confinement—this rather reminds us of Isaac Walton, who told his pupil to put the hook into the worm "tenderly, as if he loved it"—in each bottle was a metal tube of a particular form, and which was made somewhat difficult for a leech to enter, but into which it would endeavour somehow to creep before a thunderstorm, according to its nature. In each tube was a small piece of whalebone, to which a gilt chain was attached, and so arranged, on the mouse-trap principle, that when the whalebone was moved the bell at the top of the apparatus was rung by means of the chain. There were 12 leeches, so that every chance was given that one at least would sound a storm signal. The author called this apparatus the "Tempest Prognosticator," a name which he preferred—and I think we shall agree with him—to that of atmospheric electric telegraph conducted by animal instinct. He went on to state in his little book that he could, if required, make a small leech ring the great bell of St. Paul in London as a signal of an approaching storm. The book is written in all seriousness, and a number of letters are appended from gentlemen who certify that correct atmospheric indications were at various times given by the leeches. The name of the inventor of this ingenious contrivance was Dr. Merryweather—himself a learned leech.

Plants have also their advocates as weather indicators; and there is no doubt that in most cases they act in sympathy with changes in the dampness, gloominess, or chilliness of the air, and as these conditions generally precede rain, one cannot term the indications altogether fallacious. The pimpernel and the marigold close their petals before rain, because the air is getting damper, while the poplar and maple show the under surface of their leaves for a similar reason. Indeed, an artificial leaf of paper may be made to do the same thing, if constructed on the same principle as the natural one—a hard thin paper to represent the upper side of the leaf, and a thicker unsized paper for the lower side; these will, if stuck together, curl up or bend down

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in sympathy with the hygroscopic condition of the air. A slip of ordinary photographic paper will do the same, and will curl up at once when placed on the hand.

The same slackness which moisture produces in plants applies in some degree also to insects, some of which can only fly in sunshine, so that there is a chain of weather signs all following from a little dampness in the air. The flowers close their petals and shut in their honey, the insects cannot fly so high, and the swallows seeking them skim the surface of the earth, and even then the threatened shower may not come.

In 1892 attention was directed to a plant, the *abrus precatorius*, a beautiful shrub of the mimosa kind, which has the property of being sensitive in a high degree, so that its pinnate leaflets go through many curious movements, and it was claimed that these form a guide of unerring certainty to foreshow the coming weather. Even earthquakes were said to be predicted by this wonderful plant. If it closed its leaflets upward, after the manner of a butterfly about to settle, fair weather was shown; when the leaflets remained flat, changeable and gloomy weather was indicated; while thunder at various distances was to be foretold by the curling of the leaflets, and the nearer the thunder the greater the curl, until when the points of the leaflets crossed, the thunderstorm was indicated as being overhead. Changes of wind, hurricanes, and other phenomena were to be shown by the various curious and beautiful movements of the leaflets and stalks. These movements undoubtedly took place, but when the plant was submitted to the unprejudiced observation of Dr. F. W. Oliver and Mr. F. E. Weiss, at Kew Gardens, those gentlemen failed to find any connection between these movements and the weather, and Dr. Oliver made a report on the matter, which hits the heart of the whole subject of plant movements, by ascribing them for the most part to the agency of light and moisture. Mr. Scott, of the Meteorological Office, gave the finishing stroke to the theory by proving that the movements had no connection with either cyclones or with earthquakes, so that the sensitive plant may be considered as out of the list of weather guides, in spite of having been made the subject of an English patent.

It is a most common observation in the country that a large crop of hips, haws, and holly-berries indicates a severe winter to follow, and it is generally pointed out that nature thus provides winter food for the birds. This, too, is a fallacy.

Another weather fallacy, for which artists are responsible, is that flashes of lightning take the form of long angular lines of a zigzag shape, and of which I show you an example, taken from a work on the subject. This, when compared with the next view, which is a photograph taken direct from nature, shows that the artist had very little understood the true form of the lightning flash, which consists of numbers of short curves joining each other, something like the course of a river depicted on a map, or in some degree like the outline of a clump of leafy trees seen against the sky. But, as far as I know, there were only two artists whose acute vision saw lightning in anything like its true form. One was Turner, who long before the

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time of photography, scratched his lightning flashes with a penknife, making short curved dashes across the picture; and the other was Nasmyth, the astronomer and engineer, who also saw the lightning in its true form, and duly noted the same, only to be confirmed years afterwards, when it became easy to photograph the lightning flash itself. While on the subject of lightning, I may mention that it is recorded that in one case at least a rheumatic man who had been confined to bed six weeks, received a shock from a stroke of lightning, jumped from his bed, and ran down stairs completely cured. This is related in the *Gentleman's Magazine* for June 1820.

It has been often stated that the noise of cannon will produce rain, and it is not unusual in the Austrian Tyrol to hear the church bells ringing to avert thunder. These are fallacies. The experiments in America made recently to test whether rain could be produced by exploding a large quantity of gunpowder in the air, resulted in nothing except noise and smoke, though the thing was well worth trying.

Empedocles of old is credited with the invention for chasing away the Etesian winds by placing bottles made of the skins of asses on the hills to receive them. Timæus relates this. After hearing this about Empedocles, one is not surprised to learn that he thought there were two suns, that the moon was shaped like a dish, and that the sea was the sweat of the earth burnt by the sun. All this will be found in Stanley's *Lives of the Philosophers*.

Almost in our own time, too, a "pluvifuge," or machine for blowing away rain, was proposed to be constructed in Paris. This, too, was a fallacy.

To give an account of all the various ceremonies in savage and civilised countries, which have been resorted to for the purpose of changing the course of the weather, would be here impossible; but such rites have a common origin, and a common result. They begin in error, and end in failure. In India, the rain-god is imagined to pour down showers through a sieve; in Peru there was supposed to be a celestial princess, who held a vase of rain, and when her brother struck the pitcher, men heard the shocks in thunder. In Polynesia rain comes from the angry stars, stoning the sun; while in Burmah it is still the custom to haul down rain by pulling at a rope. New Caledonia has its regular rain-making class of priests, and in Moffatt's time the rain makers of South Africa were held in even higher estimation than the kings; and on the other side of the world the Alaskan propitiates the spirit of the storm by leaving tobacco for him in a cave. In our own country, too, there have been weather witches of various grades, and one described in Drayton's *Moon Calf*:—

> "Could sell winds to any one that would
> Buy them for money, forcing them to hold
> What time she listed, tie them in a thread
> Which, ever as the seafarer undid
> They rose or scantled as his sails would drive
> To the same port whereat he would arrive."

The Finlanders at one time drove a profitable trade by the sale of winds. *After* being paid, they knitted three magical knots, and told the buyer that when he untied the first he would have a good gale; when the second, a

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strong wind; and when the third, a severe tempest.[1] Sir Walter Scott also mentions that King Eric, also called "Windy Cap," could change the direction of the wind by merely turning his cap round upon his head; and old Scotch women are mentioned who, for a consideration, would bring the wind from any desired quarter.[2] The Mandan Indian rain-maker had a rattle by the noise of which he called down rain from heaven by the simple process of keeping on long enough. It is safe to say that these are all fallacies.

From the rain makers we may now turn for a moment to the almanack makers, and any one who will look up an old almanack of the early part of the last century, will find the greater part of it filled with lucubrations on the influence of the stars and constellations; he will also find a column giving for every day the parts of the body which are particularly under the celestial influences on the given dates, and when one sees for the first time this column reading—head, chest, legs, knees, feet, &c., one wonders what it can mean, but it was then so well understood, as not even to require explanation, and there was generally too a rude woodcut of a hideous human figure, tatooed with the various signs of the zodiac to show the same thing. The sort of knowledge that passed for meteorology in 1703 may be learned from the following extract from *Meteorologiæ* by Mr. Cock, Philomathemat. 1703,—a rare book in the possession of Mr. Symons.

"The twelve signs are divided into four sorts, for some be earthy, others watery, a third sort aery, and the fourth sort is fiery." The author then goes on to state that "Jupiter in the Skinker (whatever that may be) opposed by Saturn in the Lion did raise mighty South-west winds * * Observe when a planet is in an earthy sign he was lately dried up by perambulating a fiery sign, and after that, immediately having made his progress in an earthy sign, is quite bound up from moisture."

It seems incredible that our ancestors, only a few generations back, could have bought, paid for, and believed, such stuff as this. The early almanacks boldly gave a prediction for the weather for every day in the year; but after a time confined themselves to a general statement of the weather, for instance *Partridge's Almanack* for 1835 has the following prophesy for June. "Fertilising showers attended with thunder and lightning."—this does for the first 10 days. "Fair and at times hot" for the middle of the month, and "refreshing rain for the grass and corn" for any time between the 21st and the end of the month.

Authors of weather almanacks had already begun to seek safety in vagueness. Some of these almanacks rose to a great popularity on the strength of one lucky guess; and I think it is told of this same Partridge's almanack or some other of the class, that it owed its reputation to a curious prophesy of extraordinary weather for July 31st, when hail, rain, snow, thunder, &c. were freely indicated. Forgetting that the month had 31 days the almanack maker had omitted to insert the weather prediction for the last

[1] Olaus Magnus, *Hist. of the Goths*, 1638.
[2] Notes to *The Pirate*.

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day, and a boy was sent from the printing office to know how the space was to be filled up. The weather prophet was too busy to attend to him, but at last in a passion, said: "put down hail, rain, snow, thunder, anything;" and the boy taking it literally told the compositor who duly set into type the extraordinary prediction, and which by a freak of nature came true, and made the fame and fortune of the almanack maker. This story if not true is at least "*ben trovato*," and shows the force of the bard's statement

> "Our indiscretion sometimes serves us well
> When our deep plots do pall."

The *British Almanack* for 1831, published by the Usefnl Knowledge Society, had no weather predictions.

Patrick Murphy published a popular weather almanack, and his fame is said to have commenced by a lucky hit in one of the earlier issues by which he indicated which would be the coldest day of the year. There is a copy of this almanack for 1838, in the library of the Society, and some former owner has evidently taken the trouble to pencil in the actual weather opposite to that predicted. There were according to this annotation 89 incorrect forecasts, 91 doubtful, and the rest correct.

This Patrick Murphy was not a mere charlatan. He had a system, and though he differed from Sir Isaac Newton and the Royal Astronomical Society, he gave much study and research to the subject of meteorology—as shown by his various books. There was an Astro-Meteorological Society as late as 1861, and we have some numbers of its *Records* in our library.

Next comes the subject of weather prophets as distinguished from mere almanack makers; and who profess, sometimes for pelf, at other times for honour and glory, to predict the weather for any future date. These are always arising, and they do not lack a certain number of followers, who, possessing a large angle of credence, duly trumpet forth the successes of their chiefs, when they are so fortunate as to make any. The stock-in-trade of a prophet is of a slender and cheap description. He must have an inventive mind, a store of self-confidence, an insensibility to ridicule, and, above all, a keen memory for his successes, and a prompt forgetfulness of his failures. He should by choice have a theory, and this should be of the elastic order, so that if a predicted event does not punctually occur, he will be ready with a sort of codicil to amend it. Hence we find that the firing of guns has been cited as a sufficient reason for falsifying a weather prediction; and railways too are said to have an adverse influence, one author (not a prophet) telling us that they may be considered as "large winnowing machines, perpetually fanning and agitating the air with prodigious power, ploughing the air as it were and causing waves of vast extent, which, invisibly enlarging like the waves of the ocean, probably meet each other, clash, and produce modified effects, as resultants from adverse motions."

One of the first weather prophets mentioned in that delightful old book, Stanley's *Lives of the Philosophers*, was Democritus, the Milesian, known as the "laughing philosopher," who foresaw a dearth of olives, and by buying

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up all he could get might have made a fortune, but gave it back to the bargainers with the remark, "you can see now that a philosopher can get rich when he pleases." Then there was Pherecydes, of whom Pythagoras was a favourite pupil, who predicted an earthquake three days in advance by the taste of the water from a certain well. Perhaps the earliest of all was Elijah, who from the top of Carmel pointed out the coming squall cloud, and predicted a great rain. He forms a good model for imitation to the modern weather prophets, for he did not prophecy until he saw the storm coming, and he made no secret of his method. We have still amongst us in our country, mostly without honour, seers who supply us with weather predictions in various forms, from the modest duodecimo almanack to the flaring broadsheet which compels attention; but it would be a task too long to enter on a systematic refutation of their contradictory guesses at the weather. The last of these broadsheets that caught my eye had for the days of the gale, which Mr. C. Harding has described to us, the tame announcement of "generally overcast." This did not err on the side of boldness when considered with reference to one of the severest gales of the century.

A Spanish peasant whom I heard of in Andalucia, and who had the reputation of a weather prophet, wisely said, if you want to know the weather for to-morrow, ask me early in the morning. The Indian weather prophets who made a failure had to be silent altogether for the rest of their lives; and this causes us to regret that some of our own seers were not born in that distant land.

As to the so-called weather forecasts, they only come under the title of this paper when they fail, and as 8 out of 10 are said to be correct, I shall only say that they are honest attempts on the part of civilised governments to warn their people as far as possible against the march of known disturbances. I could wish that the term "weather indications" or "indicated weather" had been adopted, so as to make this plain to all, and that oftener, when the signs were vague, we had the simple announcement of no change indicated.

The director of this system so well known to us, and who is playfully called the "Clerk of the Weather," sometimes receives valuable hints, even from children; and I must quote one such communication.

"Please, Mr. Clerk of the Weather, tell the rain, snow and hail to stop for the afternoon, and rain in the night."

I may conclude this section by saying that it is a great fallacy to suppose that there is such a thing as a weather prophet. All the great authorities agree that in the present state of our knowledge no human being can correctly predict the weather, even for a week to come.

And now we must consider a class of weather fallacies of which the victims can only excite in a well regulated mind feelings of sadness and compassion, rather than the ridicule to which at first sight they seem more naturally entitled. I mean those weather prophets in whom the delicate mechanism of the mind is touched by disorder or decay, even if it has not

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already fallen under the stroke of complete dementia, and who believe that they can not only foresee the weather, but, by an effort of their own minds, control the elements and compel the clouds.

These patients I had hoped only existed in small numbers; but, on perusing the correspondence of a prominent meteorologist, kindly lent me for the purpose, I find that there are many of this class whose name, like that of the ancient wanderer among the tombs, is "Legion," and who still come on, each prepared to drive the chariot of the sun, or by an exertion of his own will, odylize (the word I suppose will come) all the powers of nature.

Hear what Dr. Johnson's Astronomer says in *Rasselas:*—"Hear me, therefore, with attention. I have diligently considered the position of the earth and sun, and formed innumerable schemes, in which I changed their situations. I have sometimes turned aside the axis of the earth, and sometimes varied the ecliptic of the sun, but I have found it impossible to make a disposition by which the world may be advantaged. What one region gains another loses. Never rob other countries of rain to pour it on thine own."

This type of patient, as well as those who would use their supposed power for the purpose of creating fine weather during the holidays of the people, belong to the more noble sort, but there have been others, like the notorious Friar Bungay, who for sordid reasons have professed to exert a similar power. The only wonder is that anybody ever believed them.

Now, as this malady of the mind is not incurable, I will venture to offer a practical suggestion, and would recommend these patients who have nursed themselves into the belief that they possess the keys of the weather, to seek the hill top on a summer afternoon—the air and exercise will do them good—and watch the fine fleeces of cumulus cloud as they sail majestically across the sky, each with its attendant shadow below. Let the patient concentrate his attention upon one single feathery cloud, and try by the exertion of his utmost force of will to make it pause for a moment in its career; and, if he fails—"as fail full well he may"—then let him banish from his mind for ever the idea that he can by his own will dominate the whole firmament. And if he has ever gone into print upon the subject, let him go home and, like Prospero, his prototype, say:—

> "Deeper than ever plummet sounded,
> I'll drown my book,"

and so save the world from the trouble of investigating much pure nonsense. To these sufferers I can only repeat the words of one of our own kings to the last man he touched for the evil—"I wish you better health and more sense."

I must be forgiven for having only made a selection from the vast catalogue of fallacies which have accumulated about the subject, and I must continue to regret that there are still people who are ready to believe that the saints' days rule the weather, that the sun puts out the fire, that warm

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water freezes sooner than cold, or that a man is a prophet because he says so himself.

This Society is clearing the ground of many weeds, and already the fallacy of the "equinoctial" gales has been exploded (by Mr. Scott), while the churchyard ghost of the supposed fatal "green Christmas" has been most effectually laid by a recent statistical paper by Mr. Dines.

Some one may ask, after all this clearing away of fallacies—What have we left? and I would venture to refer him to all the patient work which is being done in various countries, and by which a real Science of Meteorology is being slowly built up, while to the outdoor weather student I would offer this consoling reflection—There is still the sky.

REPORT OF THE COUNCIL

FOR THE YEAR 1894.

In presenting their Report, the Council have to congratulate the Society on its steady progress during the past year. There is a slight increase in the number of Fellows elected, over the number elected in 1893, and the balance at the bank, at the end of the year, is larger than the balance then brought forward.

Committees.—The Council have been materially assisted by several Committees, which have been constituted as follows:—

Editing Committee.—The President, Rear-Admiral Maclear, and Mr. Scott.

Exhibition Committee.—The President, Secretaries, Foreign Secretary, Messrs. T. W. Baker, Ellis, and Capt. Wilson-Barker.

Fog Committee.—The President, Secretaries, Foreign Secretary, Messrs. Ellis, Russell, and Williams.

General Purposes Committee.—The President, Secretaries, Foreign Secretary, Treasurer, Messrs. Ellis, Latham, and Williams.

Wind Force Committee.—The President, Secretaries, Foreign Secretary, Messrs. Chatterton, Curtis, Dines, C. Harding, and Munro.

House Accommodation Committee.—The President, Secretaries, Foreign Secretary, and Dr. Williams.

Exhibition.—The Exhibition of the year was both interesting and instructive. It illustrated "Clouds: their Representation and Measurement," and was held, as usual, in the rooms of the Institution of Civil Engineers, and was open from April 10-20. There were 135 exhibits, classified as follows:—

(1) Instruments for ascertaining the direction of motion, and the height of clouds.

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(2) Thermometers.
(3) Hygrometers, evaporators, &c.
(4) Marine instruments.
(5) Anemometers.
(6) Travellers' instruments.
(7) Barometers.
(8) Sketches and photographs of clouds.
(9) Sketches and photographs of meteorological phenomena.
(10) Photographs and diagrams of instruments.
(11) Lantern slides and transparencies.

The exhibit by Mr. W. Dillworth Howard attracted general attention. It consisted of a portrait of, and two original drawings of clouds by, his grandfather, the celebrated Luke Howard, F.R.S., the author of the *Modifications of Clouds*, 1803. Through the kindness of Mr. Dillworth Howard, a copy of the portrait appears as a frontispiece to the July number of the *Quarterly Journal*.

Lectures.—A suggestion having been made that a course of lectures on "Meteorology in Relation to Hygiene" would be much appreciated by Medical Officers of Health and others, the Council approached the Sanitary Institute on the subject, the result being that a course of six lectures was given under the joint supervision of the Society and the Institute, between April 23rd and May 10th, at the Parkes Museum, as follows:—

(1) April 23rd, by G. J. Symons, F.R.S., on "Instruments and Observations and their Representation."

(2) April 26th, by H. R. Mill, D.Sc., F.R.S.E., on "Temperature of Air, Soil, and Water."

(3) April 30th, by R. H. Scott, M.A., F.R.S., on "Barometric Conditions and Air Movements."

(4) May 3rd, by W. Marriott, F.R.Met.Soc., on "Moisture, its Determination and Measurement."

(5) May 7th, by C. Theodore Williams, M.A., M.D., F.R.C.P., on "Climate in Relation to Health, and the Geographical Distribution of Disease."

(6) May 10th, by F. Gaster, F.R.Met.Soc., on "Fog, Clouds, and Sunshine."

These lectures were printed by the Sanitary Institute in their *Journal*, and through the kindness of a member of our Council extra copies of the part containing the lectures were obtained from the Institute in sufficient numbers to ensure the distribution of one copy to each Fellow.

Stations.—Observations have been accepted from the following new Stations:—Penzance, Cornwall; and Haverfordwest, Pembrokeshire. The observations have been discontinued at Lynsted, Newton Reigny, and Carmarthen. Copies of detailed monthly returns, and annual summaries of results have been supplied as usual to the Meteorological Office.

Inspection of Stations.—All the Stations south of lat. 52° N. and east of long. 2° W., and such new stations as could be conveniently visited, have

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been inspected, and been found to be, on the whole, in a satisfactory condition. Mr. Marriott, in his Report (which will be found in Appendix I., p. 65), states that he has called the special attention of the observers to the necessity of carefully adjusting the Campbell-Stokes sunshine recorder.

Research Fund.—This fund has been augmented by a donation of £10 from Mr. W. M. Beaufort, and also by the sum of £2 1s. 6d. interest received.

Donations.—Considerable additions have been made to the Library during the year, of which a list will be found in Appendix V., p. 81. Several photographs and lantern slides have been received from different donors.

Quarterly Journal.—This publication has contained several papers of considerable interest, more particularly those dealing with storms and wind force measurement.

Meteorological Record.—This publication has been brought up to June, 1894, and is now in the fourteenth year of its existence.

Phenological Report.—This interesting and instructive annual Report was, as usual, prepared and was read by Mr. Mawley at the February meeting, and it is satisfactory to find that the number of observers has been well maintained.

Offices.—Early in the year the Council were informed that the remaining room on the second floor of 22 Great George Street, would be vacant at Michaelmas. A Committee was appointed to consider the desirability of increasing the accommodation, and on receiving their report the Council, having regard to the growing needs of the Library, took the room on a lease similar to, and running concurrently with, the old lease. The room has now been furnished, and is a great acquisition to the Society.

Hour of Meeting.—The change of the hour of the evening meetings from 7 p.m. to 8 p.m. has not proved conducive to a large attendance, owing to the late hour to which the business extended, and the Council in view of this fact, and of numerous representations made to them, decided to alter the time of commencement to 7.30 p.m. during the coming Session, and to close every meeting not later than 9.30 p.m. The Council hope that this arrangement will be found more convenient.

Fellows.—The changes in the number of Fellows are exhibited in the following table, which shows an increase of six during the year.

Fellows.	Annual.	Life.	Honorary.	Total.
1893, December 31st...	406	135	17	558
Since elected	+39	+4	+2	+45
Deceased.....	−10	−1	−2	−13
Retired.....	−24	...	...	−24
Lapsed.....	− 1	...	...	− 1
Defaulter	− 1	...	...	− 1
1894, December 31st...	409	138	17	564

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Deaths.—The Council have to announce with much regret the deaths of eleven Fellows, and of two Honorary Members. The names are :—

Edwin Clark, M.Inst.C.E., F.R.A.S.	elected Mar. 19, 1862.
Padre Francisco Denza (Honorary Member)	,, June 15, 1870.
Wilhelm A. von Freeden (Honorary Member)	,, June 17, 1874.
George Garnett, M.Inst.C.E.	,, May 17, 1876.
John Hill, M.Inst.C.E.	,, Nov. 16, 1881.
Robert Lawson, LL.D., F.S.S.	,, Apr. 18, 1888.
John Lovel	,, Mar. 18, 1891.
Henry Bean Mackeson, F.G.S.	,, Nov. 16, 1881.
Capt. John Shortt, R.N. [died in 1893]	,, Dec. 18, 1889.
William Topley, F.R.S., F.G.S., Assoc.Inst.C.E.	,, June 15, 1892.
Rev. John Turner Wilkinson, M.A., LL.D.	,, Dec. 19, 1888.
Henry Woolcock, Assoc.M.Inst.C.E. [died in 1892]	,, Dec. 17, 1890.
Henry Yool	,, Nov. 20, 1878.

APPENDIX I.

Inspection of Stations, 1894.

ALL the stations in the south-eastern part of England (that is south of 52° N. lat., and east of 2° W. long.), as well as three new stations in the south-west, have been visited during the year, and were found to be generally in a satisfactory condition.

The observers appear to take an intelligent interest in the work, and to be anxious to supply trustworthy data from their stations.

The number of thermometers tested has been 141. Changes of zero have taken place in 12 thermometers; 8 mercurial having risen and 4 spirit having gone down since the last examination. In a few cases the thermometer tubes had shifted somewhat, so that the divisions on the tube did not coincide with those on the scale. These I adjusted where possible.

Some of the maximum and minimum thermometers had back plates with ring only. In such cases I either put on fresh back plates having a hole and slot, or subsequently forwarded them to the observer for him to put on.

At one station the maximum thermometer was out of order, and had been so for several weeks. This is the first instrument of the Negretti and Zambra pattern which I have found to fail, and act as an ordinary thermometer, after 2 or 3 years' service.

Most sunshine recorders of the Campbell-Stokes pattern were somewhat out of adjustment, the glass ball not being in the centre of the frame. This is readily tested by passing a sovereign round between the ball and the card. If the sovereign passes round uniformly, the ball is in the centre of the frame; but if it sticks at any point the instrument requires readjustment. This is done by moving the pedestal until it is quite in the centre of the frame.

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In what is called the "universal sunshine recorder" the ball is kept in position by being clamped axially. Unless this be very carefully adjusted and attended to, the ball will slide down a little and put the instrument out of focus; furthermore, the edge of the frame will also cut off the early and late rays of the sun. Consequently some of the record will be lost.

I would recommend all observers who have a burning recorder to occasionally test this adjustment by simply passing a sovereign round between the ball and the card.

WILLIAM MARRIOTT.

October 13th, 1894.

NOTES ON THE STATIONS.

ADDINGTON HILL, *September 13th.*—The observations appeared to be correctly taken, and the instruments to be kept in good order. The maximum thermometer (Negretti and Zambra's pattern) had for a few weeks been acting as an ordinary thermometer. As the constriction had evidently become ineffective, I recommended that the thermometer be sent forthwith to the makers for repair. I put on fresh back plates to the minimum thermometer. The screen required painting.

ADDISCOMBE, *September 13th.*—Miss Mawley had removed from Lucknow House, but the instruments still remained in the garden, the observations being taken by the gardener. It is probable that the station will be discontinued at the end of the year. There was no change in the instruments.

ASPLEY GUISE, *September 11th.*—This station was in good order, but as Mr. Dymond was away from home I did not test the thermometers. The ball of the sunshine recorder was not quite in the centre of the frame.

BEDDINGTON, *September 13th.*—This station was in good order. The tubes of the thermometers required fixing and adjusting.

BENNINGTON, *September 21st.*—This station was in good order. On comparing the thermometers it was found that the grass minimum had gone down 0°·5.

BERKHAMSTED, *September 11th.*—This station and all the instruments were in good order. The ball of the sunshine recorder was not in the centre of the frame.

BEXHILL-ON-SEA, *September 5th.*—I found that Mr. C. Wiggins had charge of Mr. Tenison's instruments, but that he was not observing with them, nor could he undertake to supply records. He promised, however, to forward the sunshine values from the Jordan recorder, which is still continued at the Coast Guard station.

BOURNEMOUTH, *August 21st.*—I inspected and examined the instruments at the stations both at the Cemetery and the Coast Guard. The Corporation have not, however, yet decided that the results of the observations may be published by the Society.

BRIGHTON, *September 4th.*—There was no change in the thermometers. The grass minimum had some spirit separated. The screen required

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painting. As it is possible that the spray from the fountain may sometimes reach the rain gauge, I recommended that the display of water should be regulated in windy weather, or the rain gauge moved. The ball of the sunshine recorder was not quite in the centre of the frame. This I adjusted. The upper part of the frame for the small (winter) cards is taken off in the summer to prevent the ends cutting off the sun's rays.

CHELMSFORD, *August 31st.*—There was no change in the thermometers. The minimum had a little spirit at the top of the tube which I shook down. The screen required painting and also to be made firmer.

CRANLEIGH, *July 20th.*—This station is at the Surrey County School; and the instruments are in a railed off enclosure in a field on ground sloping to the south. I recommended that the position of the maximum be altered in the screen. The grass minimum had some spirit at the top of the tube.

DITCHLING, *September 4th.*—The instruments are placed on a small lawn, and are surrounded by wire netting about 6 feet high. I recommended that this should be reduced to about 3 feet only. Ditchling Beacon is nearly two miles to the south, and rises to a height of 750 feet.

EASTBOURNE, *September 5th.*—On comparing the thermometers I found that the minimum read 0°·2 too low. The index of the grass minimum did not move freely down the tube; there was also a speck or two of dirt. Evidently the tube was imperfect, and this accounted for the index sometimes getting out of the spirit. The screws for the maximum and minimum required tightening to prevent vibration. Scarlet runners had been allowed to grow somewhat near the rain gauge. The sunshine recorder is on the tower of the Grand Hotel. The ball was not quite in the centre of the frame.

FOLKESTONE, *September 7th.*—This station is at the Sanatorium on the East Cliff. The instruments are in a small railed off enclosure, the observations being taken by the matron. The thermometers required rearranging in the screen. The sunshine recorder (Jordan twin-instrument) is on the roof of one of the buildings. The hills probably intercept a little of the early and late sunshine.

GUERNSEY, *August 18th.*—As the trees have grown somewhat considerably of late years, I recommended that the rain gauge be moved to the large lawn, where there will be a good exposure. The tube of the minimum was loose and had slipped down. This I re-adjusted. The screen required painting. The sunshine recorder appeared to be 15 minutes slow. The late evening sun is just cut off by the roof.

HALSTEAD, *August 31st.*—The instruments were in good order. The minimum appeared to have gone up 0°·3.

HARESTOCK, *August 22nd.*—The station and instruments were in good order. The ball of the sunshine recorder was not quite in the centre of the frame. Colonel Knight has had a hole made for taking observations with a 70 feet earth thermometer.

LISS, *August 25th.*—This station, which is on the crest of the hill, has a good exposure. The sunshine recorder (universal pattern) was not working correctly, as it was not set for the proper latitude. I levelled the instrument

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and set it to the proper latitude, but could not adjust it for time as the sun was not then shining.

MARGATE, *July 13th.*—This station was in good order. The minimum had gone down 0°·5. The sunshine recorder (universal pattern) is mounted on a brick pier on the roof of the house. The ball had slipped down somewhat and was not in the centre of the frame, and consequently the edges of the frame cut off some of the early and late sunshine.

MARLBOROUGH, *July 11th.*—There was no change in the thermometers. Bean sticks had been put in close to the rain gauge. These I requested should be removed. The trace of the sunshine recorder was not parallel with the card. This was owing to the frame not being properly fixed with the ball in the centre.

NEWQUAY, *July 24th.*—The thermometer screen is placed in a field not far from the cliff, in a very open situation. The rain gauge is placed in a kitchen garden on the south side of the main road. The sunshine recorder is mounted on the ridge of a stable, and is well exposed. The ball was not quite in the centre of the frame.

OLD STREET, LONDON, *August 29th.*—In the early part of the year the minimum for some time read about 3° too high. Another minimum, which was used in its place, also read 3° or 4° too high. It was discovered afterwards that a bubble had been generated in the tube near the bulb. I recommended that the tree near the rain gauge should be cut back.

PENZANCE, *July 25th.*—The instruments are in the Morrab Gardens, on a level lawn in front of the Library. I recommended that the screen and rain gauge be shifted, so as to be out of the influence of the sloping bank. The thermometers required rearranging in the screen, and new back plates to be put on the maximum and minimum. The observer was instructed to read the thermometers to tenths of a degree. The two sunshine recorders (burning and photographic) are mounted on a platform on the south side of the dome of the market hall; the exposure is very good. The early and late sun's rays were not recorded by the burning instrument, as the ball had slipped down and was consequently not in the centre of the frame. This I readjusted.

PORTSMOUTH, *August 23rd.*—On comparing the thermometers it was found that the dry and wet had gone up 0°·1. I recommended that the thermometers should be read to tenths of a degree. The sunshine recorder was mounted on top of the screen and did not get the evening sun. I suggested a more suitable exposure for the instrument, and also recommended that the traces be fixed before being measured. As an additional building will shortly be erected, it is probable that the rain gauge may have to be moved to the north kitchen garden.

PRINCETOWN, *July 26th.*—The instruments were in good order, the stand having recently been painted and the outside cylinder of the rain gauge soldered. I brought away with me the spare set of thermometers.

REGENT'S PARK, *August 29th.*—There was no change in the thermometers. The screen required cleaning and painting inside. The

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sunshine recorder is mounted on a wooden tower. Owing to the shrinkage of the wood the recorder was somewhat out of level.

SHEERNESS-ON-SEA, *September 20th.*—There was no change in the zeros of the thermometers, but the grass minimum had 8°·6 of spirit at the top of the tube. The position of the maximum and minimum in the screen required altering. I recommended that the screen be painted and that the trees be cut back as much as possible.

STRATHFIELD TURGISS, *July 10th.*—This station was in good order. The thermometers are mounted in the old Kew screen. On comparing the thermometers it was found that the dry bulb had gone up 0°·1.

SWARRATON, *August 22nd.*—There was no change in the thermometers. The muslin on the wet bulb required renewing.

TAVISTOCK, *July 26th.*—The thermometers were in the kitchen garden on ground sloping rapidly from north to south. I recommended that they be removed to the terraced lawn at a lower elevation, on which the rain gauge is also placed. If this were done Mr. Glyde would have no difficulty in taking evening observations.

TENTERDEN, *September 6th.*—The sunshine recorder is placed in a garden on the east side of the road, and removed at 9 a.m. to a post at the end of Mr. Mace's garden on the west side of the road. By this means all the available sunshine is recorded.

TUNBRIDGE WELLS, *September 17th.*—On comparing the thermometers it was found that the minimum had gone down 0°·4. The screen required painting. Mr. Smart had had the frame of the burning recorder (universal pattern) cut in two places with the view of letting down the eastern flap in the morning and the western flap in the afternoon, as he believed the edges of the frame cut off the sun's rays. The ball, however, was not in the centre of the frame.

VENTNOR, *August 24th.*—On comparing the thermometers it was found that the minimum had gone down 0°·2. I had the rain gauge attended to by the engineer, as the funnel fitted tightly and the outer cylinder had been dented by croquet balls.

WALLINGTON, *September 13th.*—The instruments were removed in June to Malden road, about 150 yards from their former position in Manor road. The exposure is good. The sunshine recorder is placed on the roof of the house.

WEYMOUTH, *August 20th.*—The station was in good order. The minimum had about 0°·2 of spirit at the top of the tube. Mr. Eyles had just got a burning sunshine recorder, which he had mounted on a tripod on the top of the house at the end of the pier. The ball was not quite in the centre of the frame.

WORTHING, *September 3rd.*—There was no change in the zeros of the thermometers. As the end of the tube of the maximum was broken off and the tube loose, I readjusted it and made it secure.

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APPEN-

STATEMENT OF RECEIPTS AND EXPENDITURE

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance from 1893				168	10	4
Subscriptions for 1894	666	1	0			
Do. former years	51	0	0			
Do. paid in advance	43	2	0			
Life Compositions	84	0	0			
Entrance Fees	36	0	0			
				880	3	0
Meteorological Office—Copies of Returns	112	12	10			
Do. Grant towards Inspection Expenses	25	0	0			
				137	12	10
Dividends on Stock (including £40 11s. 4d. from the New Premises Fund)				113	12	9
Sale of Publications				30	7	10
				£1330	6	9

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DIX II.

FOR THE YEAR ENDING DECEMBER 31ST, 1894.

EXPENDITURE.

	£ s. d.	£ s. d.
Journal, &c.:—		
Printing Nos. 89 to 92	130 6 3	
Illustrations	28 17 11	
Authors' Copies	15 16 6	
Meteorological Record, Nos. 51 to 54	48 1 0	
Registrar-General's Reports	8 8 0	
		231 9 8
Printing, &c.:—		
General Printing	19 3 0	
Stationery	18 2 9	
Forms	6 2 0	
List of Fellows	9 12 6	
Books and Bookbinding	15 17 0	
		68 17 3
Office Expenses:—		
Salaries	413 10 0	
Rent and Housekeeper	156 5 6	
Furnishing new room, Repairs, Coals, &c.	53 15 5	
Postage	58 10 1	
Petty Expenses	15 7 6	
Refreshments at Meetings	14 7 8	
Exhibition Expenses	8 5 11	
Lecture Expenses	19 1 5	
		739 8 6
Observations:—		
Inspection of Stations	43 18 11	
Observers	9 2 0	
Instruments	1 4 0	
		54 4 11
Stock:—		
Purchase of £41 5s. 7d. 2½ per cent. Annuities		42 0 0
		1135 15 4
Balance:—		
At Bank of England	184 18 4	
In hands of the Assistant-Secretary	9 13 1	
		194 11 5
		£1330 6 9

Examined and compared with the Vouchers, and found correct,

R. H. CURTIS,
FREDC. GASTER, } *Auditors.*

January 10th, 1895.

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APPEN-

ASSETS AND LIABILITIES

Liabilities.

	£	s.	d.
To Subscriptions paid in advance	43	2	0
,, Excess[1] of Assets over Liabilities	2983	1	6
	£3026	3	6

[1] This excess is exclusive of the value of the Library and Stock of Publications.

Examined,
R. H. CURTIS,
FREDC. GASTER, } *Auditors.*

WILLIAM MARRIOTT, *Assistant Secretary.*

January 10th, 1895.

NEW PREMISES FUND,

	£	s.	d.
Amount paid to the Society's Funds towards the increased rent of the New Premises	40	11	4
	£40	11	4

Examined,
R. H. CURTIS,
FREDC. GASTER, } *Auditors.*

WILLIAM MARRIOTT, *Assistant Secretary.*

January 10th, 1895.

RESEARCH FUND,

	£	s.	d.
Amount invested in purchase of £101 0s. 3d. 2¾ per cent. Consols at 99	100	0	0
Do. Do. £11 14s. 2d. at 103¾	12	1	6
	£112	1	6

Examined,
R. H. CURTIS,
FREDC. GASTER, } *Auditors.*

WILLIAM MARRIOTT, *Assistant-Secretary.*

January 10th, 1895.

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DIX II.—Continued.

ON JANUARY 1ST, 1895.

ASSETS.	£ s. d.	£ s. d.
By Investment in M. S. and L. R. 4½ per cent. Debenture Stock, £800 at 152	1216 0 0	
,, ,, in N. S. W. 4 per cent. Inscribed Stock, £654 18s. at 108½	710 11 8	
,, ,, in L. & N. W. R. Ordinary Stock, £200 at 177	354 0 0	
,, ,, in 2½ per cent. Annuities, £141 5s. 7d. at 101¼	143 15 0	
		2424 6 8
,, Subscriptions unpaid, estimated at	50 0 0	
,, Entrance Fees unpaid	16 0 0	
,, Interest due on Stock	30 13 9	
		96 13 9
,, Furniture, Fittings, &c.	215 12 1	
,, Instruments	94 19 7	
		310 11 8
,, Cash at Bank of England	184 18 4	
,, Cash in hands of Assistant-Secretary	9 13 1	
		194 11 5
		£3026 3 6

DECEMBER 31ST, 1894.

	£ s. d.
Interest received on investment	40 11 4
	£40 11 4

NOTE.—The Society holds on account of this Fund £1199 0s. 2d. South Australian 3½ per cent. Inscribed Stock.

DECEMBER 31ST, 1894.

	£ s. d.
Contribution by Dr. C. T. Williams	100 0 0
Do. ,, Mr. W. M. Beaufort	10 0 0
Interest received on investment	2 1 6
	£112 1 6

NOTE.—The Society holds on account of this Fund £112 14s. 5d. 2¾ per cent. Consols.

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APPENDIX III.

OBITUARY NOTICES.

EDWIN CLARK was born at Marlow on January 7th, 1814, and was the eldest of three boys. (His brother, Latimer Clark, F.R.S., is well known in the scientific world.) After boarding at an old school in the town, he was at the age of eleven sent to a French school in Normandy, where in three years he acquired such a thorough knowledge of French that his translation of the *Chronicles of the Canongate* into French was published in France. He returned home in 1828, and was placed in a solicitor's office; but scientific tastes seriously interfered with his application to this work. Such tastes were but little understood at the time, and the boy was regarded by all his friends as a ne'er-do-well. But his diligence and attention to science, especially in its practical aspects, ultimately bore fruit. He obtained a position as teacher in his old school, and one of his colleagues, who was reading for the University, strongly urged the advantage he would derive could he go up for honours at Cambridge. A small legacy which his mother received at this time was devoted to this purpose. But at the end of two and a half years his parents found it impossible to continue his maintenance at the University. After some engagements as schoolmaster, Mr. Clark resolved on an apparently reckless project. He had long wished to see something of the world, and with £10 in his pocket and a knapsack on his back he started on a wild and indefinite tour on the Continent. He visited the Rhine, Switzerland, and crossed the Alps into Italy, making observations on glaciers and meteorology, and various scientific collections. He became an artist, and continued his tour through Rome to Naples, Pompeii, Salerno, Pœstum, and at length returned to his home at Marlow in 1839, to the great delight of his parents. He at once accepted a mathematical mastership at Coombe Wood, and then at Brook Green, Hammersmith, and collected a small library and a stock of scientific apparatus.

But this profession did not hold him long. In 1845 the railway mania had resulted in the great financial crisis which threw so many surveyors and engineers out of employment, and at this inopportune juncture he suddenly abandoned the school to assist in the survey of the proposed line between Brighton and Oxford. This project speedily collapsed, but Clark's determination to be an engineer was taken. With an introduction of the most slender character, he repaired to Mr. R. Stephenson's chambers in Great George Street, an office that was destined afterwards to become his own for so many years. Mr. Stephenson was at that time overwhelmed with work, especially in the great contest between the broad and narrow gauge, and Mr. Clark was at once informed of the hopeless improbability of a personal interview. But, nothing daunted, he waited patiently for hours every day in the ante-room during a period of three weeks, and at last was rewarded by a chance interview. He was fortunate enough to be able to prove his

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abilities almost immediately, and the foundation of his career as an engineer was laid.

The problem on which he won his spurs was that of the Britannia and Conway Tubular Bridges, for the construction of which he was ultimately placed in absolute control as resident engineer. He was for many years chief engineer to the Electric Telegraph Company, and invented and patented the hydraulic graving dock and canal lift. He constructed the great dock at Bombay, and others at Malta and London. He was the designer of a host of bridges, including the great swing bridges at Arnheim, Lyons, and Rochester, the Aire Tubular Bridge, and the Scarborough Viaduct. He was the original inventor of the block system of signalling. Mr. Clark also laid the cable from Dungeness to Holland, and negotiated the agreements and erected the telegraph for the chief English railways. He was engineer to the Crystal Palace Company, and completed the building of the Palace after the fire.

Mr. Clark retired from business in 1876, and after travelling for two years in South America, he settled down at Great Marlow, where he devoted himself to astronomical and meteorological observations. He died from cancer on October 22nd, 1894.

He was elected a Fellow of this Society on March 19th, 1862.

Francisco Denza.—The following notice is abridged from the *cenni necrologici* of Padre Denza:—

By the death of Father Francisco M. Denza, which occurred on December 14th, 1894, not only has this our college of S. Carlo a' Catinari, to which he belonged since 1890, and that of Moncalieri, to which he had been attached for a number of years, sustained a very great and sad loss, but the whole of our congregation is equally affected by it. Father Denza was in Italy one of the most assiduous cultivators of natural science, and in meteorology, to which he devoted himself with the greatest diligence, no one could contest the victory with him. The "Specola Vaticana," reclaimed to new life by the munificent wisdom of Leo XIII., loses in him more than a Director and Father, who by the authority of his name and his constant activity, had raised it to be one amongst the first observatories of Europe. But above all, we can testify that he was a man who united in himself all the rigidness of the most modern culture with the sincerity of an ancient faith, and to his scientific labours the assiduous study of religious perfection. Our order possessed in him not only an illustrious member, as he is now denominated, but an obedient son and an indefatigable worker. Born at Naples, of Michele and Virginia Zigzi, June 7th, 1834, at the age of 17 he requested to be clothed with our habit (of a Barnabite), which he accordingly was invested with in 1850. He first studied in our College of S. Filippo, in Macerata, and then was sent to Rome, where, under the celebrated Padre Secchi, he devoted himself to mathematics and physics until 1857, when he was sent to the university of Turin. He then founded an observatory which became the central one of the Italian Meteorological Society, well known in

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the world of science. He continued his lectures in this university, and had pupils from every part of Italy until 1886, when he had a paralytic stroke; but he recovered sufficiently from it to be able to fill the office of Vice-Rector, and to help many by his ability and long experience. As he grew in years his fame grew also.

He published many pamphlets on science and on observations on eclipses, on the Aurora Borealis, on the falling stars, and on the variations of the magnetic needle, &c. One popular treatise on Astronomy is his "*Armonie dei Cieli*," published repeatedly, and he translated into Italian Mr. Scott's *Elementary Meteorology*.

If in the present day upwards of 200 observatories are spread over our country, which in that respect is inferior to few others, it is due to the powerful influence of our dear Father. Thus the "*Corrispondenza Meteorologica Italiana Alpino-Apennina*," founded by him in 1859, and "*La Societa Meteorologica Italiana*," constituted in 1882 under the Hon. Presidency of H. M. King Umberto I., under the effectual direction of our Father Denza, have become two national institutions.

He also attended many congresses held for the diffusion of science. In 1878 we find him at the International Congress of Meteorology in Paris, in 1879 at Rome. In 1881 we find him in the month of April at Algiers for a Scientific Congress, in September at Milan for the Subalpine Congress, and in October at Venice for the General Geographical Congress. In 1884 he represented the Holy Father at the Congress of the Scientific Association of France at Rouen, and took advantage of this journey to France to visit Holland and England. In December 1887, although still suffering from a second attack of apoplexy, he went to Rome to be present at the jubilee of Leo XIII., and remained until February 1888 in order to co-operate in the Scientific Exposition of the Clergy, and in the following year promoted the Institution of "la Specola Vaticana," of which he was appointed Director by the Pope, and took up his residence in a modest apartment prepared for him. To that institution he devoted four years of assiduous work, spending part of the summers at the Royal College of Moncalieri.

In 1892 fresh symptoms of his former malady appeared, and being taken suddenly ill just after having had an audience of the Pope, he expired 24 hours after, having received all the comfort of the last sacraments and benediction of the Holy Father.

Such was the external glory of this beloved Father, which only was generally known; but we who were well acquainted with him can appreciate the truer and more hidden glory of his Christian virtues. The Royal College of Carlo Alberto owes to him a great portion of the fame it enjoys, not only in Piedmont, but all over Italy, and in Father Denza it has suffered a very great loss.

Meanwhile, his name will remain blessed amongst us, and may it lead many others to cultivate science with the same activity and rectitude that he did.

He was elected an Honorary Member of this Society on June 15th, 1870.

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WILHELM ADOLF VON FREEDEN was born at Norden in East Friesland, May 22nd, 1822, and died at Bonn, January 11th, 1894, after a short attack of inflammation of the lungs. From 1845-56 he was Teacher of Physics in the Gymnasium at Jeven, and from 1856-67 Director of the Navigation School at Elsfleth near Bremen.

He is best known to science as the Founder and first Director of the Norddeutsche Seewarte at Hamburg, an Institute which in 1875 was reorganised as an Imperial Establishment under its present name, the Deutsche Seewarte, Dr. G. Neumayer being appointed Director. Herr von Freeden at this date withdrew to Bonn, where he spent the remainder of his life, occupying himself *inter alia* with the editing of the *Hansa*, a newspaper he had started.

He took a principal part in the founding of the North German Lloyds Company. The activity of the Seewarte under his management was most creditable, and numerous papers from his pen have appeared in the *Zeitschrift der Oest. Met. Gesellschaft*, and elsewhere.

He was for five years, 1871-6, Member of the Reichstag for Hamburg, but declined re-election on removing to Bonn.

He was elected an Honorary Member of this Society on June 17th, 1874.

JOHN HILL, M.Inst.C.E., was at the time of his death one of the oldest county officials in Ireland. He was appointed Chief Surveyor of Clare in 1845, an office which he held for about 10 years, when he went to King's County to fill a similar position. After 12 years' service there he renewed his connection with Clare in 1867, and remained County Surveyor till his retirement in 1893. He was for several years Chairman of the Town Commissioners, and also Vice-Chairman of the Clare Castle Harbour Board.

He died on January 23rd, 1894, aged 81.

He was elected a Fellow of this Society on November 16th, 1881.

INSPECTOR-GENERAL ROBERT LAWSON was born in 1815, and belonged to an Aberdeenshire family. He entered the army as an Assistant Surgeon in 1835, became Surgeon in 1845, Deputy Inspector-General in 1854, and Inspector-General of Hospitals in 1867, and retired on half-pay in 1872. He was present at the storming and destruction of the fortified Mandingo town of Sabajee on the Gambia in 1853, and served in the Crimea during 1854 and 1855. He received the Crimea medal with Sebastopol clasp, the 4th class of the Medjidieh and the Turkish medal. The degree of LL.D. was conferred upon him in 1884 by the University of Aberdeen, and he was appointed one of the Honorary Physicians to the Queen in 1891.

When serving in the West Indies and the West Coast of Africa, he showed early the scientific bent of mind that pervaded the whole of his career by observations regarding meteorology and the laws of storms—a subject which was at this time little regarded and only in its infancy. He was one of the earliest to draw attention to the rotation theory of cyclones, but his work in

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this respect, like much of his later work, was ahead of his time, and did not attract the notice it deserved. He further made valuable observations concerning the spread of malarial disease and yellow fever by means of air-currents and prevailing winds, and the natural means of protection from their spread by such causes. There are now only two officers alive who ever served as Inspector-General of Hospitals, a rank which became obsolete under the Royal Warrant of March 1st, 1873.

His retirement from the army in 1872 did not entirely break his connection with the service, as he acted on several commissions, and assisted in the development of the modern system of ambulance. He was an active member of the Epidemiological and Statistical Societies, and was president of the former. In their Transactions and elsewhere a large number of publications have appeared from his pen at various times, dealing chiefly with the methods by which cholera and other epidemic diseases are spread; and he delivered the Milroy Lectures, in 1888, on Epidemic Influences, Yellow Fever, and Cholera. Perhaps the best known of his labours, at least among the general profession, were those referring to the progress of epidemics from north to south of the earth at a given rate of progress at right angles to the distribution of the isoclinal lines of the magnetic dip, which were termed the pandemic waves. Having access to the records of the Army Medical Department, he collected a great body of statistics bearing on this point showing the influence of these waves on all infectious diseases.

Whilst serving in the army he was eminently just and kind to all under him, and the advocate and true friend of those who showed any unusual industry, ability, or merit. His sense of duty was always very strong, and he never spared himself in the way of personal trouble and painstaking to discharge such duties as fell to his lot conscientiously and well.

He died at Aberdeen on February 8th, 1894, at the age of 79.

He was elected a Fellow of this Society on April 18th, 1888.

JOHN LOVEL was born at Halperthorpe, Yorkshire, on December 13th, 1862, and was early left to the care of his father, his mother dying in February 1866. He received most of his instruction from his father, who for some years kept an elementary school at Weaverthorpe. After being apprenticed for several years to a joiner and wheelwright, Mr. John Lovel in 1883 joined his father at Driffield, who three years before had purchased a part of the site he at present occupies, which he prepared for, and has since carried on, as a strawberry nursery.

Twelve years ago the father commenced rainfall observations, which so interested Mr. John Lovel that in 1890 he organised a climatological station, and became a valued observer for the Royal Meteorological Society.

After the waterspout and flood at Langtoft in July 1892, Mr. John Lovel made a study of the question of waterspouts and cloudbursts, and communicated a paper on the subject to the Royal Meteorological Society.

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He also sent to the Society the results of a year's comparative observations, which he had made with two sets of maximum and minimum thermometers, read and set at 9 a.m. and 9 p.m.

Mr. John Lovel had a thorough appreciation of, and was well in touch with, every day subjects. He was a most enjoyable companion, and ever ready to impart in a quiet way some interesting fact or other relating to the great problems of nature.

He died on February 16th, 1894, aged 31 years.

He was elected a Fellow of this Society on March 18th, 1891.

William Topley, F.R.S., F.G.S., Assoc.Inst.C.E., was born at Greenwich on March 13th, 1841. He was educated in local schools, and entered the Royal School of Mines in 1858, which he left in 1862, and joined the staff of the Geological Survey of England and Wales, being initiated into the methods of field-work by Dr. Le Neve Foster, with whom he jointly brought out a remarkable paper in 1865 on the "Denudation of the Weald," proving that the formation of the Weald of Kent and Sussex, its central ridge and surrounding Downs, alike owed their origin to the long continued sculpturing of rain and rivers. Mr. Topley surveyed important areas, both amongst the Wealden and Cretaceous rocks of Kent and the Coal Measures of the North of England; of the former area he wrote a Survey Memoir of a most exhaustive character, in which he embodied the whole of the existing knowledge; the work is remarkable for a combination of scientific methods and work with a bibliographical instinct which was characteristic of the mind of the author. In 1880 Mr. Topley was recalled from field-work to take charge of the publication of maps and memoirs at the London office of the Geological Survey, a post he held till his death.

He joined the British Association in 1872, and served as Secretary and Reporter of Section C (Geology) between that year and 1888 no less than 15 times. To the Working Committees he was ever ready to give valuable aid; he joined the Circulation of Underground Waters Committee in 1883, but had previously assisted in the work, since its initiation on the suggestion of Dr. Hull in 1874, while the valuable reports of the Coast Erosion Committee were wholly drawn up by him; this Committee was suggested by Mr. De Rance in 1881, Mr. Topley from the first acted as its Secretary, and secured the assistance of the War Office, Admiralty, and other Government Departments; he had intended to present the final Report and recommendations this year. He was early placed on the Sub-Wealden Exploration Committee, and in 1872 was officially sent down by the Geological Survey to record the phenomena observable, on which he presented a valuable report. His paper on "the Geological Distribution of Gold and Silver," read at the British Association, was ordered to be printed *in extenso* by that body.

In contributions to the Royal Agricultural and other Societies, he opened up a new field of research, in the relation of parish boundaries to the geological structure, and the influence of the latter on water supply, character of the surface of the ground, and even of climate,

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To the International Geological Congress in 1888 he acted as one of the secretaries, and had been previously appointed in 1881 to superintend the publication of the British Section of the International Geological Map; and he gave to the recent Royal Commission on London Water Supply long-continued and valuable assistance in the illustrations and tables accompanying their Report.

Medical science has benefited by the assistance given by him to Sir George Buchanan's researches on *The Distribution of Phthisis as affected by the Dampness of the Soil*, and by his address on "Geology in relation to Hygiene," given in 1890, when Chairman of the Geological Section of the Sanitary Institute.

He took an active part in the commencement of *The Geological Record*, and eventually became its editor in 1887, a post for which his great knowledge of bibliography well fitted him. His power of work and industry were remarkable, and it is infinitely to be regretted that his wonderful enthusiasm impelled him ever to assist all who asked him for aid, as, by the constant drain on his reserve of force, he fell a ready victim when attacked by gastritis in Algeria, against which he struggled in vain, though he reached his home at Croydon, only to die in a few days, on September 30th, 1894. Whether as an officer of the Survey, or Sectional Secretary of the British Association, or President of the Geologists' Association, or scientific worker, or in his home life relations, we find him ever willing to work, to help, and to assist those around him, and to endeavour to make life pleasant. His work in numerous most useful directions has ceased, but his kindly memory will long be remembered, and lines of investigation he has suggested be followed up, perhaps by those who hardly realise the first initiation that led to their researches.

He was elected a Fellow of this Society on June 15th, 1892.

APPENDIX IV.

BOOKS PURCHASED DURING THE YEAR 1894.

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BEAVER, P.—African Memoranda; relative to an attempt to establish a British setttlement on the Island of Bulama, on the western coast of Africa, in the year 1792. 4°. (1805).

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TIMBS, J.—Knowledge for the People. Part XVI. Meteorology. 12°. (1832).

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APPENDIX V.

DONATIONS RECEIVED DURING THE YEAR 1894.

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APPENDIX VI.

REPORTS OF OBSERVATORIES, &c.

THE METEOROLOGICAL OFFICE. — Lieut.-Gen. R. Strachey, R.E., C.S.I., F.R.S., Chairman of Council; Robert H. Scott, M.A., F.R.S., Secretary; Nav. Lieut. C. W. Baillie, F.R.A.S., Marine Superintendent.

MARINE METEOROLOGY.—*Current Charts for all Oceans.*—The additions made to these charts during the year have consisted in the entry of any currents which have come in from recent voyages. Among these may be mentioned observations taken on board H.M. ships, and a series of observations from the Indian Ocean and Western Pacific, received from the Imperial Austrian Navy. The work of generalising the currents has now been undertaken; this is an operation requiring much consideration and judgment. It is not yet decided whether it will be advisable to bring out twelve monthly charts for each ocean, or whether (*e.g.*) quarterly charts will meet the requirements of sailors.

The Red Sea.—These charts are now complete, and will be issued in the course of the spring.

The Meteorology of the South Sea.—The extraction and discussion of materials has been finished, and the charts are now in process of preparation for the engravers.

The South Atlantic.—Good progress has been made with the examination and extraction of data. The region is very extensive, and the mode of treatment required will probably be different in different parts of the area.

The second edition of the *Barometer Manual for Seamen* has been published.

WEATHER TELEGRAPHY.—The only addition to the Weather Reporting Stations during the year has been that the Swedish Government has forwarded reports from Carlstad on Lake Wener.

The Rain Tables for the British Isles for the decade 1881-90 are in the press. The values for England have been printed, and the information for Scotland and Ireland is less copious, so that it can soon be set up. The preparation of tables for back lustra, for such stations as were not contained in the previous publication, and for which data for periods earlier than 1881 exist, will now be proceeded with.

LAND METEOROLOGY OF THE BRITISH ISLES.—The volume of *Hourly Mean Readings for five-day periods for the Four Observatories* in 1891 has not yet appeared, but that for 1892 is in an advanced stage, awaiting the completion of the hourly tabulation of sunshine, as mentioned in last year's Report.

Mr. Dines' pressure tube anemometer has been in action in the Office in London for two years, and it is now contemplated to erect some of these instruments at coast stations, as at Scilly or Holyhead, where there already exist other instruments, with which the indications yielded by Mr. Dines' apparatus can be compared.—*March 11th*, 1895.

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ROYAL OBSERVATORY, GREENWICH.—W. H. M. Christie, M.A., F.R.S., Astronomer Royal.

The rapid gearing by means of which the registering sheet of Osler's anemometer could be made to travel at 12 times the ordinary speed having been found to work satisfactorily, a further change was introduced in the month of July enabling records to be made at a speed of 24 times the ordinary rate.

Numerous records have been made on this extended scale in high winds with satisfactory results, and the scale is now considered to be sufficiently opened out. Information relating to the gale of December 22nd has been furnished to Mr. C. Harding.

On account of the extension of the buildings for the north wing of the New Physical Observatory to the southern boundary of the Meteorological enclosure, it has been found necessary to remove the thermometer stand and the Stevenson screen to temporary positions near the north front of the photographic thermometer shed, but the final positions for these instruments have not yet been arranged. One rain gauge has also been shifted to a more open situation. Care has been taken to prevent interference to the instruments by workmen during the progress of building operations.

The abstracts of the observations of the temperature of the air for the 50 years 1841-1890 have been completely passed through the press, and the introduction (in the printer's hands) is alone wanting to complete this work, which will be now ready for issue in a very short time.

The mean temperature for the year 1894 was 49°·9, being 0°·5 above the 50 years' average. The maximum temperature was 86°·0 on July 6th, and the minimum 12°·8 on January 5th. The total amonnt of sunshine for the year was 1,052 hours, being 400 hours less than in 1893. The total rainfall amounted to 26·89 ins. on 192 days.—*April 8th*, 1895.

ROYAL OBSERVATORY, EDINBURGH.—Ralph Copeland, Ph.D., F.R.S.E., Astronomer Royal for Scotland.

The daily meteorological readings have been continued as in former years, together with weekly observations of the rock thermometers. The same large discrepancy as before is shown between the rain gauge on the roof and that on the grass 22 feet below, the upper gauge catching only 18·53 ins. in 1894, as compared with 28·02 ins. at the lower level.

It has not yet been practicable to begin observations at the new Observatory, but it is hoped that the meteorological instruments will be in full working order before the close of the summer.—*February 16th*, 1895.

KEW OBSERVATORY OF THE ROYAL SOCIETY, RICHMOND, SURREY.—Charles Chree, M.A., Superintendent.

The several self-recording instruments for the continuous registration of atmospheric pressure, temperature of air and wet-bulb, wind (direction and velocity), bright sunshine, and rain, have been maintained in regular operation throughout the year, and the standard eye observations for the control of the automatic records duly registered.

The tabulations of the meteorological traces have been regularly made, and these, as well as copies of the eye observations, with notes of weather, cloud, and sunshine, have been transmitted, as usual, to the Meteorological Office.

Early in the year a new "worm" spindle was fitted to the direction fans of the anemograph, and the square-headed pricker was replaced by a round one, made of extra hardened steel. At the same time the direction pencil was "trued" in the lathe to improve the marking, and later on the velocity spiral was similarly treated.

The analysis of the value of the residual corrections mentioned in last Report indicated that a re-determination of the barograph scale was expedient. This was carried out at the Meteorological Office, and showed that the old value of 1·569 ins. in the curve ordinates to 1 in. of pressure should be replaced by one of 1·553 ins. The new value has been employed since January 1st, and the irregularities of the residuals have been much less marked from that date.

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The electrograph has been in regular action during the year, with the exception of about 11 days in January and 19 days in August, and its general performance has been satisfactory. Advantage was taken of the frost in January to dismount the whole of the instrument, to remove the old acid in the jar and insulators, and give the apparatus a general overhauling. At the same time the scale was slightly opened out. The suspension thread was accidentally broken on August 16th, but it was replaced, and the instrument re-started on September 4th.

Determinations of the scale value were made on March 30th, June 26th, and December 27th by direct comparison with the portable electrometer, White No. 53. The value of the scale divisions of this latter instrument was kindly determined by Prof. Carey Foster at University College Laboratory during February, and the value for one division found to lie between 197—205 volts. These experiments confirmed the scale value heretofore employed, viz. 1 scale division = 200 volts.

The observations of a series of distant objects, in fog and mist, have been continued. A note is taken of the most distant of the selected objects which is visible at each observation hour. An analysis of the results for the period May 1892 to December 1893 has been prepared and forwarded to the Meteorological Council.

At the instance of the Meteorological Council an electrical anemograph, with an improved arrangement for recording wind direction, has been under trial for some months.

To throw light on the results obtained with Lord Kelvin's water-dropper electrometer, a series of observations have recently been made for the Meteorological Office on the distribution of electric potential in the neighbourhood of the Observatory.

A grant of £30 has been obtained from the Royal Society Government Grant Committee for the purpose of conducting a research on the behaviour of aneroid barometers. The work of constructing the air pump and other apparatus required was entrusted to Mr. J. J. Hicks. He has unfortunately experienced considerable mechanical difficulties, which have delayed the construction of the apparatus. It is hoped, however, it will be ready for use at an early date.

During the year the temperature ranged from 14°·0 on January 5th, to 83°·4 on July 6th. The mean temperature was 49°·9. In the sun's rays (black bulb *in vacuo*) the maximum reading was 138° on July 8th ; and the lowest reading of a thermometer freely exposed on the grass was 11° on January 5th and 6th.

1,851 hours of bright sunshine were recorded, giving a mean percentage of 29, which is the average value.

The only month calling for notice was March, when the percentage was 44, which is 15 per cent. above the average for the past 17 years, and the highest value yet obtained for that month.

The rainfall, 28·02 ins., is the heaviest since 1880. There were 3 daily falls exceeding an inch, viz. 1·11 ins. on July 10th, 1·43 ins. on July 29th, and 1·36 ins. on October 30th.—*March* 1*st*, 1895,

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RADCLIFFE OBSERVATORY, OXFORD.—E. J. Stone, F.R.S., Radcliffe Observer.

No change in the routine or staff has been made during the year. The gelatino-bromide paper has been used for the photographic registers ; and the records of the photographic and self-recording instruments have been satisfactory throughout the year.

The eye-readings of the instruments have been taken as usual, and reports sent daily by telegram to the Meteorological Office, monthly to the Registrar-General and the local newspapers, and to sanitary and other authorities on request.

During the visit of the British Association to Oxford, the Observatory was thrown open to Members and Associates, and a large number availed themselves of the opportunity of visiting the Observatory.

The following are the chief characteristics of the weather noted at Oxford in the year 1894 :—

The mean temperature of the air for the year was 49°·1, being 0°·3 above the

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mean for the last 66 years. The highest temperature in the shade was 82°·5 on July 1st, and the lowest 11°·1 on January 5th, the difference being 71°·4. The highest temperature in the sun's rays was 131°·4 on July 6th, and the lowest on the grass 2°·5, on January 5th.

The total rainfall was 30·101 ins., being 3·853 ins. above the mean for the last 79 years. The largest monthly quantities of rain were 3·519 ins. and 4·964 ins. in October and November respectively; whilst from November 7th to 14th (inclusive) 4·346 ins. fell, resulting in extensive floods.—*February 11th*, 1895.

THE GALE OF DECEMBER 21st-22nd, 1894, OVER THE BRITISH ISLES.

By CHARLES HARDING, F.R.Met.Soc.

(Plate I.)

[Read January 16th, 1895].

It has been customary for some time past that the occurrence of any exceptional meteorological phenomenon should form the subject of a paper for reading at a meeting of the Society—a custom which has the advantage not merely of bringing out the special features in connection with the different phenomena, but as time goes on we are collecting a series of papers on various subjects which are of interest to the Fellows, and which may prove useful outside the immediate sphere of the Society. The present paper has been undertaken on the above grounds, and it has been treated much in the same manner as former papers which I have prepared on similar subjects.

The storm was one of exceptional severity over the northern portions of England and Ireland and in the south of Scotland. It developed energy very quickly, and travelled with great rapidity across the country. For some time previous to the storm gales were of frequent occurrence on our north and west coasts, and storm systems had been skirting our west and north coasts with great persistency, the disturbances following very much the same track when in close proximity to our coasts.

At 8 a.m. on December 21st the barometer was falling in nearly all parts of our Islands, and in Scotland and Ireland the fall in many places exceeded 0·8 in. since the preceding morning. The wind had backed from North-west to the Westward and South-westward, and the force had dropped decidedly, while rain had set in at many of the western stations. The Meteorological Office remarked that "Further depressions are approaching our western coasts, and mild unsettled weather seems probable over the United Kingdom generally, with freshening South-westerly winds on our western coasts." The barometer readings ranged from 29·54 ins. at Sumburgh Head to 30·20 ins. at Scilly and Prawle Point.

The 2 p.m. reports showed that the fall of the barometer was continued,

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the decrease since 8 a.m. being greatest at Belmullet, where the fall amounted to 0·22 in. in the 6 hours. The rain area had considerably extended, but there was no material increase in the wind, Scilly being the only station reporting more than a fresh breeze, and there the wind was only force 6.

At 6 p.m. the fall of the barometer was still in progress over the entire Kingdom, and in the west the decrease was very rapid. The barometer was now as low as 29·84 ins. at Stornoway, while at Scilly the reading was 30·05 ins. The wind had everywhere become South-westerly and Southerly, and a fresh gale had already set in at Belmullet, while winds were freshening at all the western stations. The barometric fall was, however, as yet not rapid over the eastern portion of the Kingdom.

There was now ample evidence of an impending storm, and the following statement, based on the 6 p.m. reports, was issued by the Meteorological Office:

"The depression which is approaching the west of Scotland is evidently of considerable depth, and is likely to occasion gales from the South-westward and Westward over nearly the whole of the United Kingdom, with heavy rain in some of the western and northern districts."

The storm-signals were at this time flying on all coasts.

At 8 a.m. on the 22nd the observations show that during the night a sudden and most important change had taken place. A large storm area had swept across the north of Scotland, and the centre was now over the North Sea, not far to the eastward of the Moray Firth. The barometric fall was exceedingly large, amounting to more than an inch at all the northern and north-western stations, and at Aberdeen the fall in the 24 hours, since 8 a.m. on the 21st, was 1·60 in. A very violent gale was blowing in all parts of the British Islands, the observer at Malin Head reporting force 12 of Beaufort's scale. The wind at this time had shifted to the North-westward in nearly all parts of the Kingdom. Under the influence of this large disturbance a gale was blowing in the Gulf of Bothnia and along the whole distance to the west coast of France, a distance of about 1,400 miles.

The 2 p.m. reports show that the disturbance was passing away quickly to the eastward, and a very decided rise of the barometer was in progress. The lowest reading now was 28·88 ins. at Sumburgh Head, while at Valencia the reading was 30·04 ins. The North-westerly gale was still blowing at many places on our coasts, but the wind was generally subsiding, although at Aberdeen force 11 was reported.

At 6 p.m. the wind was still further subsiding, although the gale was persistently blowing on the Irish and on our east coasts. The central area of the disturbance was now close to Christiansand on the coast of Norway, where the barometer was reading 28·55 ins., the core, or heart, of the storm having perceptibly shallowed or filled up.

At 8 a.m. on the 23rd, the wind had subsided over the whole of the British Islands, and the equilibrium seemed for the time to be thoroughly restored. There was no station in the United Kingdom reporting a stronger wind than a fresh breeze. The barometrical rise was equally as rapid as the

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fall, the recovery since 8 a.m. of the 22nd being 1·65 in. at Aberdeen, and exceeding an inch at most of the northern and north-western stations.

I have made a collection of the anemograph records for different parts of the Kingdom, and give in Table I. the hourly velocities for 16 stations in the United Kingdom. The hourly velocities are given at each station for the whole time that the velocity was 45 miles or above at any station in any part of the Kingdom. In one part or another 45 miles an hour—a fresh gale, force 8 of Beaufort's scale—was maintained for 23 consecutive hours.

TABLE I.—WIND VELOCITY IN MILES PER HOUR, DECEMBER 21, 22, 1894.

Hour.	Valencia.	Dublin.	Armagh.	Orkney.	Aberdeen.	Alnwick.	North Shields.	Fleetwood.	Liverpool.	Holyhead.	Yarmouth.	Berkhamsted.	Greenwich.	Kew.	Falmouth.	Scilly.
21st																
10 p.m.	48	36	30	35	22	22	30	37	35	51	14	10	17	19	30	32
11 ,,	58	41	38	46	28	17	29	36	43	50	17	14	22	22	34	35
Midt.	59	46	46	48	26	23	39	38	36	57	19	16	26	26	38	42
22nd																
1 a.m.	56	32	48	44	25	28	47	49	40	58	22	20	28	29	42	43
2 ,,	56	32	44	40	29	42	54	55	46	64	25	21	32	35	46	46
3 ,,	57	33	44	41	30	47	55	71	54	51	28	20	30	40	46	47
4 ,,	61	29	38	33	26	62	47	76	63	52	31	24	36	40	40	46
5 ,,	59	33	42	31	25	62	52	79	66	55	34	26	41	40	34	52
6 ,,	53	31	43	17	21	79	57	86	72	58	35	30	40	33	34	52
7 ,,	58	28	40	10	11	72	61	97	76	58	32	25	31	22	39	52
8 ,,	50	30	36	54	19	60	57	101	81	59	32	31	34	29	37	52
9 ,,	43	33	27	76	35	45	45	107	79	66	38	29	37	28	34	52
10 ,,	40	28	29	82	39	48	37	103	78	65	37	30	40	30	37	50
11 ,,	31	25	25	83	56	61	45	104	89	68	44	34	46	36	44	56
Noon	38	31	21	77	60	65	55	99	80	71	49	40	50	36	43	48
1 p.m.	38	26	17	71	60	60	52	98	80	61	53	39	45	40	42	44
2 ,,	33	22	15	68	60	63	46	97	77	58	52	37	50	36	45	42
3 ,,	31	20	12	63	53	53	46	96	68	59	52	34	45	33	41	41
4 ,,	26	12	16	60	47	35	39	85	59	52	49	31	40	28	35	36
5 ,,	20	12	14	55	44	44	32	79	57	49	44	29	40	28	31	31
6 ,,	26	12	12	48	34	38	32	71	48	44	37	25	44	33	28	29
7 ,,	25	11	9	43	40	30	24	55	45	40	38	20	31	21	28	27
8 ,,	23	9	11	35	34	30	20	47	44	35	34	22	30	23	21	25

The factor 8 has been retained throughout this paper for the reduction of the anemometrical records, as no systematic change has yet been adopted either in this country or abroad, and the use of the factor 8 admits of ready comparison with all previous records. The numerous experiments, however, conducted in recent years by Mr. Dines and others, tend to show that the wind velocities obtained by the use of the factor 8 should probably be reduced by one-fourth to obtain the true velocity. The anemometers used are not all of the pattern known as the large Robinson; those at Dublin, Berkhamsted, and Scilly are of a smaller size.

The highest hourly velocity in Table I. is 107 miles, recorded at Fleetwood at 9 a.m. on the 22nd, and at that station the velocity exceeded 100 miles for the 4 consecutive hours from 8 to 11 a.m. This is the greatest force of wind

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ever registered in the British Isles, and is 10 miles an hour in excess of the highest wind velocity in the great storm of November 16th-20th, 1893. The highest velocity previously recorded at Fleetwood was 91 miles an hour, in the gale of May 20th, 1887.

In my discussion of the Storm of November 16th-20th, 1893, a Table was given showing the dates of gales from 1869 to 1893, with a wind velocity of 80 miles an hour and upwards. That table shows that there have been 21 gales in the United Kingdom since 1869 in which the hourly velocity of the wind has attained 80 miles, and only 3 gales during the last quarter of a century in which the wind has attained a velocity of 90 miles an hour.

TABLE II.—FORCE OF WIND INDICATED BY VELOCITY ANEMOMETERS.

Station.	Maximum Velocity.			Hours with Velocity			Mean Hourly Velocity for 23 hours.
	Miles.	Direction.	Date.	45 Miles and above.	65 Miles and above.	85 Miles and above.	
Valencia	61	W	22 4 a.m.	11	...	...	43
Dublin	46	SSW	21 Midt.	1	...	...	27
Armagh	48	SW	22 1 a.m.	2	...	...	29
Orkney	83	NNW	22 11 a.m.	13	6	...	50
Aberdeen ...	60	NW and NWbN	22 Noon to 2 p.m.	6	...	...	36
Alnwick	79	S	22 6 a.m.	13	3	...	47
North Shields ...	61	SWbS	22 7 a.m.	14	...	...	44
Fleetwood	107	W	22 9 a.m.	20	16	11	77
Liverpool	89	W	22 11 a.m.	18	11	1	62
Holyhead	71	NWbW	22 Noon	20	4	...	56
Yarmouth	53	WbS	22 1 p.m.	5	...	...	35
Berkhamsted ...	40	W	22 Noon	...	...	...	26
Greenwich ...	50	WSW and W	22 Noon and 2 p.m.	5	...	...	36
Kew	40	SSW and WbN	22 3 to 5 a.m. and 1 p.m.	...	...	...	31
Falmouth ...	46	SWbS and SW	22 2 & 3 a.m. 22 11 a.m.	2	...	...	37
Scilly	56	WNW		11	...	...	43

Table II. gives a few of the principal details from Table I. grouped together for purpose of comparison. The highest velocities on shore are seen to have occurred at Fleetwood, Liverpool, and Orkney. These were the only places where the maximum hourly velocity exceeded 80 miles. At Alnwick the maximum was 79 miles, and at Holyhead 71 miles. The storm was least violent at Kew and Berkhamsted, where the hourly velocity did not exceed 40 miles. The gale was of longest duration at Fleetwood and Holyhead, the hourly velocity being 45 miles, and above, at each place for 20 hours, and at Liverpool that velocity was maintained for 18 hours. At Fleetwood the hourly velocity was 85 miles, or above, for 11 hours, and the average wind velocity for 23 hours was 77 miles.

Mr. R. H. Curtis has supplied the following note on the record of the Bridled anemometer at Holyhead :—

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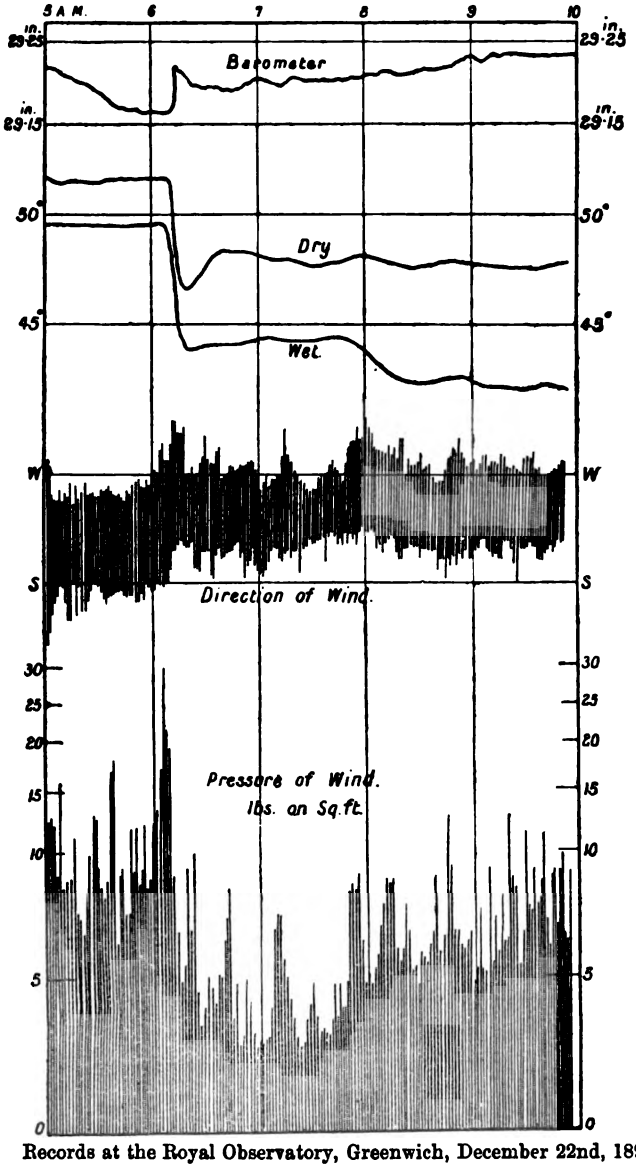
"The wind began to reach the force of a gale at 9 p.m. on the 21st, and by midnight the squalls had become very severe. It was essentially a squally gale, the velocity of the wind ranging over as much as 60 to 70 miles. The heaviest squall occurred from 10 a.m. to noon on the 22nd, and the maximum velocity recorded by the Bridled anemometer exceeded (more than once) 110 miles per hour (equal to 150 miles an hour on the basis of the old factor 3, C. H.),



Records at the Royal Observatory, Greenwich, December 22nd, 1894.

equivalent to a pressure of upwards of 36 lbs. per square foot. As early as 2 a.m on the 22nd they reached a rate of 100 miles per hour (135 miles using factor 3, C. H.), but then fell off somewhat till between 4 and 5 a.m., when the force

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increased again. After noon on the 22nd the wind fell away considerably, and after 2 p.m. no squall was experienced which much exceeded 80 miles per hour (108 miles using factor 3, C.H.), and during the evening the force became moderate."

Heavy squalls were a characteristic feature of the storm, and probably much of the damage and destruction to buildings on shore and to vessels at sea was due largely to this fact. A squall of exceptional violence passed over the Metropolis shortly after 6 a.m. on the 22nd. The Astronomer Royal has sent me tracings of the self-registering instruments at Greenwich, reproduced on p. 96, which show that this squall passed over the Royal Observatory at 6.10 a.m. A sudden rise occurred in the barometer of 0·06 in., accompanying a violent gust of wind of 28 lbs. on the square foot, and a fall of temperature exceeding 5° in amount.

The Kew records show the same squall, the instrumental readings giving the change at 6.5 a.m. The barometer rose 0·06 in., and the dry bulb

TABLE III.—RECORDS OF PREVIOUS GALES. MAXIMUM WIND VELOCITY IN MILES RECORDED IN ANY SINGLE HOUR.

Station.	1894. Dec. 21–22.	1893. Nov. 16–20.	1886. Dec. 8–9.	1886. Oct. 15–16.	1884. Jan. 26–27.	1881. Oct. 13–14.	1881. Jan. 18.
Valencia	61	60	72	58	68	58	46
Dublin	46	35	...	...	...	...	...
Armagh	48	31	...	21	69	24	...
Orkney	83	*96*	...	...	55	...	...
Aberdeen	60	46	59	45	59	*74*	...
Glasgow	...	44	34	34	50	33	...
Alnwick	79	44	44	36	*76*	...	...
North Shields	61	69	51	56	...	...	...
Fleetwood	*107*	87	*80*	42	...	...	...
Liverpool	89	49	...	38	...	...	...
Holyhead	71	89	72	62	70	...	...
Yarmouth	53	64	54	...	47	...	*88*
Berkhamsted	40	...	38	26	...	...	...
Greenwich...	50	35	...	40	58	63	...
Kew	40	38	42	32	53	45	58
Falmouth	46	55	61	59	63	57	54
Scilly	...	66	71	*78*	56	...	...

TABLE IV.—SHOWING THE FALL AND RISE OF THE BAROMETER DURING THE GALE.

Station.	Fall from 8 a.m. 21st to 8 a.m. 22nd.	Rise from 8 a.m. 22nd to 8 a.m. 23rd.
	in.	in.
Valencia	0·30	0·25
Malin Head	0·84	0·86
Donaghadee	1·01	1·09
Sumburgh Head	1·26	1·26
Stornoway	1·01	1·02
Aberdeen	1·60	1·65
Shields	1·49	1·57
Liverpool	1·01	1·10
Yarmouth	0·92	0·89
Scilly	0·46	0·53
Hurst Castle	0·66	0·74
London	0·77	0·85

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temperature fell 6°·3. At Falmouth a precisely similar squall had occurred at 4.5 a.m. on the 22nd. The barometer rose about 0·05 in., the dry bulb temperature fell 5°, and the wind changed from South-west to West.

If this was one and the same squall, its rate of travel was about 120 miles an hour. The times of occurrence at Kew and Greenwich favour the possibility of this rapid movement.

Table III. (p. 97) gives the greatest force of the wind recorded in several recent gales.

The occurrence of the lowest reading of the barometer gives a good index of the direction in which the storm travelled. The following are a few of the best marked minima :—

Valencia - -	minimum at	11 p.m.	21st.
Waterford - -	,,	Midnight	,,
Kilkenny - -	,,	2 a.m.	22nd.
Stornoway - -	,,	6	,,
Freeland, Perthshire	,,	6	,,
Sumburgh Head -	,,	7.30	,,
Stobhill, Morpeth -	,,	8	,,
Ladylaw, Hawick	,,	8	,,
Aberdeen - -	,,	9	,,
Yarmouth - -	,,	Noon	,,

The following notes on the storm have been collated from the returns kept by special observers, who from their method of regular observation would be likely to give a true estimate of the severity of the storm.

SCOTLAND.

BRAEMAR.—Violent hurricane from 9 a.m. to 5 p.m. 22nd.

BALLINLUIG.—Heavy wind. Trees blown down.

LAUDALE, ARGYLLSHIRE.—Terrific gale overnight, at height from 6.15 a.m. till 8 a.m., when wind shifted from South-west to North. Equal not experienced since 1882. Timber blown down. Barometer began to rise at 6.15 a.m.

EDINBURGH.—Barometer fell to 28·12 ins. at 6 a.m. 22nd.

ARDROSSAN.—Strong South-west gale began about 8 p.m. 21st. Veering to North-west about 4 a.m. 22nd. The maximum wind force 11 in the gusts during early part of morning. It abated somewhat just before 2 p.m. The gale was exceptionally severe, the wind seemed to come down from above in gusts, striking the ground. The average force of 10 was maintained till 2 p.m. 22nd.

CARGEN, KIRKCUDBRIGHT.—The gale on the 21st and forenoon of the 22nd was the most disastrous we have had since the gales of December 1883 and January 1884 ; great damage has been done throughout the district, the greatest damage taking place between 10 and 11 a.m. on the 22nd, the squalls during that period amounting to almost hurricane violence.

LADYLAW, HAWICK.—Severe gale, heavy rain, centre of storm passed at 7.10 a.m.

IRELAND.

CARRABLAGH, LOUGH SWILLY, DONEGAL.—6 p.m. 21st, a storm devastated this district : it laid down trees, unthatched houses, smashed boats, stripped slates, and blew down stone walls in all directions. No such storm has been known here by living people.

ROCKFORT, BUNCRANA, DONEGAL.—Fearful gale on the night of 21st and following morning from South-west veering to North-west, did immense damage to shipping on Lough Swilly and to house property.

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LONDONDERRY.—The rain gauge was blown away out of the garden on Saturday morning, 22nd, by the great storm of Friday night and Saturday morning. Nearly all the houses at the Waterside and the churches have been injured very much, and some partly blown down.

EDENFEL, OMAGH.—No storm since January 1839 has wrought such wide-spread havoc to buildings, and especially to plantations, as that of the night of Friday, 21st, and had its period of greatest violence lasted as long as on that occasion the damage to life and property would have been appalling.

OMAGH.—21st. At 8 p.m. a gale of cyclonic character rose, which increased in intensity and became almost a hurricane at midnight, and reached its period of greatest violence at 2.30 a.m., 22nd., doing immense damage. Wind South-south-east to West-north-west.

SPRINGFIELD, BELFAST.—Most severe storm on the 21st and 22nd. At 8.15 a.m. of the latter day a hurricane. Much damage done all over the country. Will be remembered hereafter as the great storm of 1894.

ARMAGH.—22nd. Great hurricane from midnight, maximum velocity of wind 48 miles about 1 a.m.

WARINGSTOWN, DOWN.—An awful storm on the morning of the 22nd, unequalled since 1839; great damage to roofs and buildings, and many trees blown down.

DUBLIN.—22nd. Violent gale from South-south-west to West-north-west last night and this morning. It was an extraordinary tempest, from the suddenness of its approach and its awful violence. Force 11 was reached at frequent intervals through the night, and some gusts merited the figure 12.

ENGLAND.

NEWCASTLE-ON-TYNE.—22nd. Gale this morning, very gusty, average velocity since about 11 p.m. yesterday equals 60 miles per hour.

CARLISLE.—This was a severe storm. It was a hurricane for 6 or 8 hours, say from midnight 21st to 8 a.m. 22nd, then a little easier.

DURHAM.—22nd. A whole gale blowing at times, 782 miles in 24 hours. From 9 a.m. to 3 p.m. it averaged 40 miles per hour.

BOLTON.—For a period of 4 hours the anemometer registered a lateral move ment of 60 miles per hour, and as the velocity was very variable, it is probable the maximum speed would be 80 miles; this would represent a maximum pressure equal to 32 lbs. per superficial foot.

ULDALE, CUMBERLAND.—The storm of 21st-22nd has done a lot of damage in this county, almost every house for miles round has suffered more or less, and the consequence is that there are so many demands upon the slaters and masons that it will be impossible for weeks to come to make good the damage done.

ULPHA, CUMBERLAND.—The gale on the 22nd was most disastrous, such a severe storm, causing so much damage, can hardly be called to mind.

WINDERMERE, WESTMORELAND.—The heaviest wind storm of the last 7 years, if at any time.

AYSGARTH, YORKSHIRE.—21st, between 7 and 8 p.m., wind began to rise from South-west with rain. At 9 p.m. it was raining hard and wind was South-west, force 7, barometer falling fast. Wind continued to increase, with heavy rain. It must have been force 10 by 2 a.m. at the least. About 7 a.m. the storm was very severe indeed, one could not put it at less than 12. Most of the damage was done at about this time. At 9 a.m. 22nd, it had shifted to West with a force of 11, and the barometer had begun to rise. Rain in night 1·5 in. Various damage reported, and a locomotive engine was said to have been capsized at Hawes Junction by the wind.

DOUGLAS, ISLE OF MAN.—The gale of 21st-22nd exceptionally severe, causing greater damage to buildings generally than any noted during the whole course of observations—upwards of 20 years.

STONYHURST.—22nd, a violent gale from midnight, wind velocity highest on record, maximum 9 a.m. 72 miles. Considerable damage done in surrounding district.

HUDDERSFIELD.—The gale of the 22nd was very severe, but here I think that those of October 14th, 1881, and December 8th, 1886, were certainly worse.

LLANDUDNO.—South-west 12 at 9 p.m. 21st.

HODSOCK, WORKSOP.—The gale on the 22nd did much damage to timber,

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buildings, and stacks. For 8 hours, from 9 a.m. to 5 p.m., the average velocity of the wind was 60·5 miles per hour.

OXSHOTT, LEATHERHEAD.—The highest velocity by Mr. Dines's recording anemometer was 56 miles per hour, this occurred in a brief squall at 5.45 a.m. The gale here was not nearly so severe in any respect as that of December 12th, 1893. Very little damage was done.

The Railway disaster to the Manchester Express at Chelford was in a great measure attributed to the exceptional violence of the wind. A locomotive was reported as capsized by the wind at Hawes Junction, and several tramcars were upset in the Midlands. In Arran it is calculated that 40,000 trees were blown down by the gale.

A feature of some interest was the very great distance that the spray was carried inland, but this has been especially dealt with by Mr. Symons in *Symons's Monthly Meteorological Magazine.*

The Secretary of the Marine Department of the Board of Trade courteously allowed me access to the official returns, which show that there were 167 lives lost on our coasts within the limit of the *Wreck Chart*, and there was also great loss of life in the North Sea, not included in the above numbers; the total lives lost are those reported up to the morning of January 16th.

The Secretary of Lloyds, Col. Hozier, states that the 23rd being Sunday the Loss Book was not posted on that day. On Monday, the 24th, there were 110 casualties posted in the Loss Book, of which a large majority were due to the gale.

The National Lifeboat Institution state that the number of lifeboat launches during the gale was 43, the number of lives saved 103, and the number of vessels saved 2.

The *Pilot Chart of the North Atlantic Ocean* for January gives the track of the storm, which shows that it traversed the Atlantic at an enormous rapidity. It was first reported on the margin of the Tropics on December 18th, and on the following day it was to the south of Bermuda. (Plate I., fig. 6.)

In conclusion, I have to thank the Meteorological Council for having so kindly placed the whole of the material in the Meteorological Office at my disposal for the preparation of this paper, also Mr. Symons for handing over to me all the material relative to the storm which has come into his hands, and others who have so readily supplied me with data.

NOTE ADDED MARCH 20TH, 1895.

The gale of December 21st-22nd was followed by a very brisk rise of the barometer, and readings were for several days abnormally high. At Valencia the mercury stood at 30·93 ins. on December 27th, a reading which is the highest recorded there with a single exception. This was followed by another very severe gale on December 28th and 29th, the wind was, however, not so violent as on December 21st and 22nd, and the area affected was more limited. The maximum wind velocity was 83 miles an

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hour at Fleetwood, the greatest violence being registered from the West-north-west at 7 a.m. 29th, and 45 miles an hour or above was maintained during the afternoon of the 28th and the whole of the 29th. At Alnwick the wind attained a velocity of 69 miles an hour from South-west-by-south at 2 p.m. 28th. At Armagh the velocity did not reach 30 miles an hour, and at Dublin the maximum velocity was 27 miles an hour.

DISCUSSION.

MR. G. J. SYMONS referred to a letter from Mr. H. S. Eaton enclosing a tracing which he had received of the deflections of a plummet suspended in a room at the summit of the Blackpool Tower (nearly 500 feet) during the prevalence of the gale described by Mr. Harding's paper. The observations were made by Mr. Ashley and Mr. Bell, and showed that the tower was deflected by the strength of the wind to the extent of about 2¼ inches. Mr. Symons further stated that he was in Liverpool when this great gale was blowing, and could speak as to its intensity by the amount of damage caused by the wind in that city. Some ten years ago, during a severe gale in the southern part of England, the foliage of trees was considerably damaged, and the question arose as to whether the injury was caused by the force of the wind twisting the stems to which the leaves were attached and so checking the flow of sap, or whether it was due to the deposition of salt brought from the sea by the wind. He (Mr. Symons) was disposed to consider that the damage was due to incrustation of salt upon the leaves, and it was curious to learn that, during the gale of last December, unmistakeable evidence was available showing to how great a distance inland the violent wind had carried sea-salt. A gentleman, a chemist, staying at Garstang, Lancashire, 10 miles distant from the sea, noticed on the day following the gale that the twigs and branches of trees, plants, grass, &c., tasted very strongly of salt. A fine drizzle subsequently set in, and some of the drops on the branches and twigs of apple trees were collected in a tea-cup, and the fluid so obtained was found to contain a very large proportion of salt. Half of the quantity of salt found was forwarded to him (Mr. Symons), and he sent it to Prof. Meldola for analysis, the result being that it was declared to be almost identical with sea-salt, the specific gravity of the liquid being nearly double that of sea-water. At Huddersfield, and at other places at a considerable distance from the sea, salt had been found upon the window panes facing the direction from which the wind blew, and even at a town so distant from the sea as Birmingham was, depositions of salt had been discovered.

ADMIRAL J. P. MACLEAR pointed out that the high velocities mentioned in the paper exceeded by 50 per cent. that given for a hurricane or typhoon in the Beaufort scale of wind force. He had experienced very severe typhoons in the China seas, and from what he had read concerning the gale on December 22nd, he did not consider that the force on that occasion was anything like the violence of a typhoon.

PROF. J. K. LAUGHTON remarked that, so far as he was aware, the extreme velocity of the wind in a tropical hurricane had never been measured; that commonly tabulated was merely an estimate, which, in view of actual measurements of storms of less intensity, must be considered much too small.

Mr. W. H. DINES agreed with Mr. Harding in thinking it better to quote wind velocities obtained by using the factor 3, rather than to make the present uncertainty still worse by giving the correct values, but it would be a great advantage if he (Mr. Harding) would state in his paper which stations had anemometers differing from the Kew pattern. Recently he, Mr. Dines, had discovered that small cups and arms were in use at the Scilly Isles, and this had explained what had long been a puzzle to him, namely the comparatively low velocities recorded there. The record at Fleetwood, which, when corrected, gave a velocity of nearly 80 miles an hour, was most remarkable, and it seemed a wonder that any buildings were left. At Mauritius, Dr. Meldrum had noted a velocity of 105 miles per hour, lasting for five minutes, and in this instance half the town was destroyed, whereas 107 miles per hour lasting for an hour, and

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100 miles maintained for four hours, had done comparatively little damage. How could the discrepancy be accounted for? There was one other point he should like to mention. The bridled anemometer and his tube anemometer had been calibrated on a whirling machine, and the velocities recorded by them were absolutely independent of the factor of the Robinson instrument. He wished to state this fact most emphatically, since the mixing up of the two instruments led to much misconception, so much so, that one gentleman in America had written to ask him what factor he had used when calibrating the tube anemometer.

THUNDERSTORM AND SQUALL OF JANUARY 23rd, 1895.

By WILLIAM MARRIOTT, F.R.Met.Soc.

[Read February 20th, 1895.]

Shortly before 10 a.m. on January 23rd, Londoners were startled by a sharp thunderstorm and heavy squall, which passed rapidly across the Metropolis.

This squall was associated with a small depression, or secondary disturbance, which passed across the country in a south-south-easterly direction. The first reported notice of thunder is from Leeds, where it was heard about 6 a.m. From this time there appears to have been a succession of thunderstorms all along the route, the last reported notice of thunder being from Crowborough Beacon, in Sussex, at 10·25 a.m.

The first sign of anything unusual occurring was the intense darkness and thick fog, which came on suddenly, and these were followed immediately by lightning and thunder, and a heavy shower of hail; the wind also rising almost instantaneously to a gale. Damage by lightning occurred at Kettering and Oundle, and also at several places in and around London. Mr. Phillpott, one of my assistants, states that when passing down Waterloo Place at 9·50 a.m. the lightning seemed to run along the side of the Duke of York's statue, and that he heard a policeman say to a comrade that he heard a cracking sound proceed from the column.

The barograph traces show a rise or jump of ·05 inch, and the anemograph curves indicate a simultaneous change in the direction of the wind from West to North.

At the Meteorological Office in Victoria Street, Westminster, the Dines' pressure tube anemograph sheet shows that the force of the wind rose almost at a bound from nearly a calm to a velocity of 36 miles an hour; and Mr. Dines's own anemograph at Oxshott recorded a similar gust of a velocity of 39 miles an hour.

The thermograph records show that there was also a sudden fall of 5° in temperature.

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The squall lasted about a quarter of an hour, and soon after the sun shone brightly, although the wind continued high for the greater part of the day.

The rate of travel of the disturbance was about 47 miles an hour.

The Astronomer Royal has kindly furnished me with a copy of the simultaneous changes of the barometer, dry and wet bulb thermometers, and the direction and pressure of the wind, at the Royal Observatory, Greenwich.

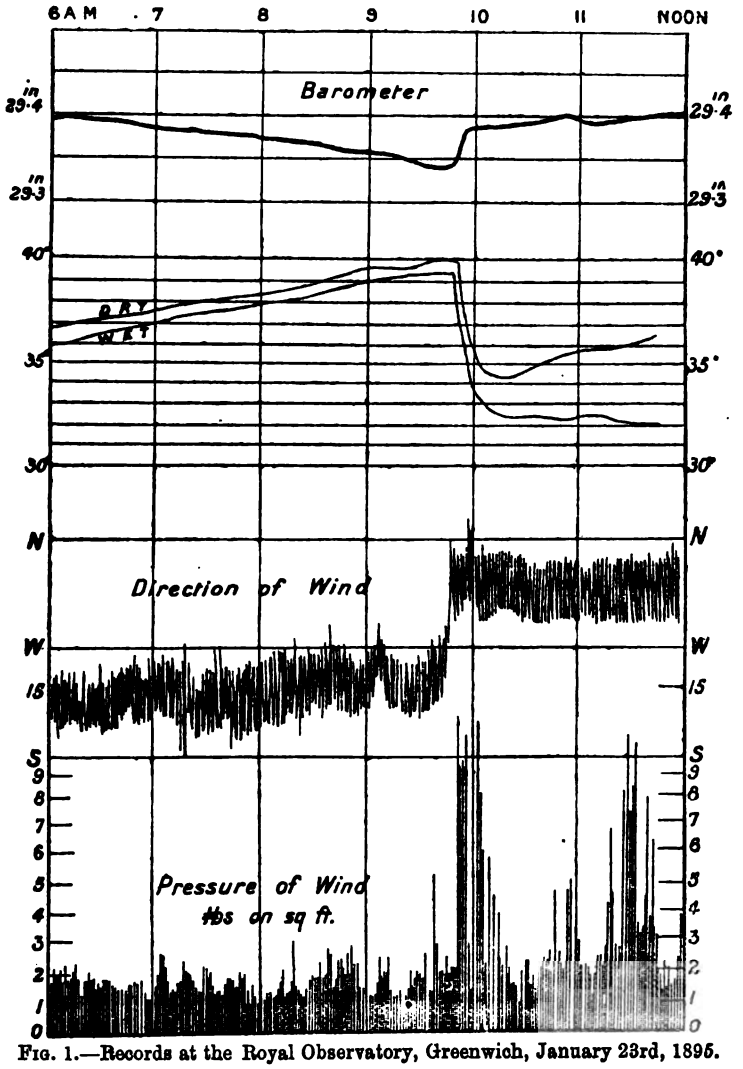

FIG. 1.—Records at the Royal Observatory, Greenwich, January 23rd, 1895.

These are reproduced in Fig. 1. The barometer is 159 feet above sea-level. It happened that the electrometer was switched to earth for its zero determination at the time of the squall, so that the indications of that instrument are not available for that time.

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Mr. J. Bartlett has supplied the following account of destruction of trees at Bramley, near Guildford:—

"A snow blizzard of great intensity, but of short duration—little more than ten minutes—occurred here about 10.30 a.m. on January 23rd, the snow falling copiously while it lasted, and the force of the wind being, as I judge, rather over, than under, 9 of the Beaufort scale.

"Before noon on that day the Hon. H. Cubitt, M.P., of Birtley House, Bramley, knowing my interest in such matters, called and invited me to go and see the devastation of trees on his property, about half a mile distant from my house. He pointed out more than a dozen trees, some of large size, laid prostrate within a length of about 350 yards. Subsequently I heard of other like damage on his property near at hand, and also in Wonersh Park, belonging to Mrs. Sudbury. The total number of trees blown down, or, in two cases, seriously truncated, amounts to 28, some of great size, and within a length of 1860 yards. Mr. Cubitt was out with his gun, attended by his gamekeeper, in the open a few yards from the spot where five spruces were prostrated, the keeper being under cover near those trees. The former states that he had to run hard to the plantation in order to avoid being blown off his legs by the wind; and a man at work on a new building near at hand told me that he had to lie down to escape being blown from the scaffolding. On the other hand, an intelligent labourer told me that he was working with others at the time on Hurst Hill, in the open, some 500 yards to the westward, and that, although they heard the loud roar of the blast below, they felt comparatively little of it.

"Hearing the next day of considerable damage at Wonersh, I went thither, and was courteously shown by young Mr. Sudbury over the scene of destruction on that property. The four trees near Wonersh church, close to the Park, are at the very south-east foot of the considerable elevation of Chinthurst Hill. It would appear to me that the blast may have swept round each side of this hill, and joined forces again in the Park. A number of trees standing isolated on the summit of Chinthurst were uninjured.

"After careful inquiry, I can hear of no damage, other than what I have named, elsewhere in this vicinity, and Admiral Maclear informs me that nothing abnormal occurred at Cranleigh, 5 miles to the southward, beyond a very sharp outburst of wind, hail, and sleet. Thus the whole devastation was limited to a line of a little more than a mile in length."

Mr. Gaster has been kind enough to redraw for me the Weather Chart for 8 a.m. on the 23rd (Fig. 2). This shows that a depression passed over the Shetland Isles during the night of the 22nd, and that it had reached Denmark by 8 a.m. on the 23rd. The isobars at the latter time ran nearly north and south over the British Isles, and were somewhat close together, indicating the prevalence of strong Northerly or North-westerly winds. An irregularity in the direction of the wind and in one of the isobars is shown over the Midlands, and this agrees precisely with the position of the thunderstorm at that hour,

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This particular storm may be classed under the head of "line" thunderstorms, as defined in my "Report on the Thunderstorms of 1888 and 1889," and is similar to the storms of May 18th-19th, 1888, and June 2nd, 1889, which I have already had the honour of bringing to the notice of the Society. In these latter cases a series of thunderstorms were tracked across England in a direct line from south to north for over 400 miles, the rate of progression being 50 miles an hour.

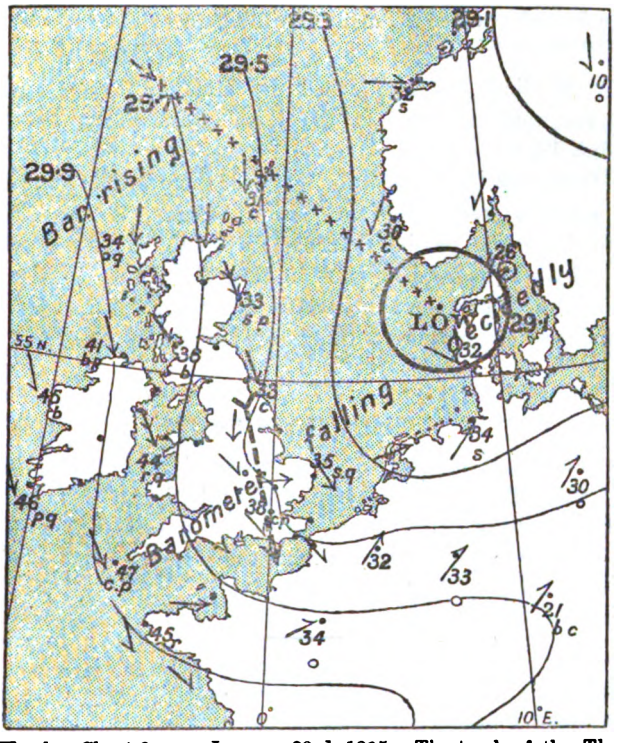

FIG. 2.—Weather Chart 8 a.m. January 23rd, 1895. The track of the Thunderstorm is also shown by the thick broken arrow.

The storm of January 23rd, 1895, however travelled in a south-south-east direction, the rate of progression being 47 miles an hour. In all these cases the thunderstorm disturbances were to the right of the main depression.

Mrs. H. S. Vinter has sent me the following extracts from the *Gentleman's Magazine* for 1767 of a thunderstorm which was followed (as was that of 1895) by a severe frost :—

Edinburgh, Jan. 8.

Last night we had a most remarkable storm of lightning attended with thunder, which continued from 9 in the evening till morning.

Whitby, Jan. 4.

On Thursday night we had here a most violent storm of wind and hail, coming from the NE, and blowing right into our harbour, causing the tide to rise near three feet perpendicularly higher than the oldest man living can remember.

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Newcastle, Jan. 10.

Last Friday and Saturday we had a great fall of snow, with lightning and thunder.

Thursday, 8.

The snow was so deep throughout the whole Kingdom that the like has not been remembered by the oldest man living. . . . The post-boys have been bewildered, and some frozen to death.

Tuesday, 13.

The principal part of the flour destined for the supply of the London Market was on board barges and other vessels, which could not come down on account of the communication by water being stopt by the frost.

Friday, 16.

The post-boy who carried the mail from Bradford to Rochdale was with his horse frozen to death.

Mr. C. Harding has also called my attention to an account of a thunderstorm which occurred at the Royal Observatory, Greenwich, on January 3rd, 1841.

In the *Greenwich Observations* for that year there is the following note :— "From accounts received from various places, it appears that this was a travelling storm, passing from north to south, at the rate of 60 miles an hour, and it was nearly 100 miles in breadth; its time of continuance at each place was nearly the same, and in every place it was preceded by a gale of wind, and accompanied with a heavy fall of rain, hail, and snow."

NOTE, MARCH 5TH.

At the Meeting of the French Meteorological Society on February 5th, M. Renou stated that at Parc-de-Saint-Maur, Paris, on January 23rd, two claps of thunder were heard to the north-west a little before 8 p.m. At Vendôme thunder was heard several times the same day; and at Châteaudun a church was struck by lightning.

DISCUSSION.

Dr. VON RICHE PRELLER observed that, having lately had to investigate, as Electrical Engineer, the effects of atmospheric electricity or lightning discharges in relation to electrical installations in various countries, he had also been led to inquire into the frequency of thunderstorms accompanied by lightning discharges both in the British Isles and in various parts of the Continent. Through the courtesy of Mr. Scott and Mr. Marriott, he had been able to examine the statistics of the last fifteen years; but he found that these statistics, valuable and excellent as they were *per se*, either referred only to particular storms, years, or isolated periods, or that they were annually compiled on principles which varied in every country, so that any attempt at comparing the frequency of such phenomena in any two countries gave a more or less negative result. The Royal Meteorological Society or the Meteorological Office would therefore render a signal service not only to meteorological, but to physical and electrical, science if, at the next International Congress, they would promote the adoption of a uniform international system of taking observations and compiling annual statistics of such phenomena. And in this connection, he might say that he thought the system adopted by Mr. Marriott in his valuable statistics of thunderstorms in England 1888 and 1889, (which is also the Swiss system,) viz. of recording the number of days on which such phenomena occurred, was at once more simple and more rational than, *e.g.* Signor Ciro Ferrari's plan of comput-

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ing the percentage of thunderstorms in each district or province of any given country.

The other point to which Dr. Preller wished to refer related to thunderstorms and lightning discharges more especially in England. From the statistics and a great many isolated notices he had examined, he arrived at the conclusion that in England there were, broadly speaking, two lines or areas of greatest frequency of lightning discharges such as accompanied the thunderstorms of 1888, 1889, and 1892, to wit, one from London in the direction of Bristol, viz. east to west or *vice versâ*, and the other from south to north or *vice versâ*, through the western rather than the eastern parts of the country, and extending, probably, also along the western counties and coast of Scotland. These two lines, and notably the one east to west, coincided remarkably with the lines or areas of magnetic attraction on the north pole of the compass needle as determined by the surveys of Prof. Rücker and Prof. Thorpe, and explained by the former in a lecture recently delivered before the Royal Geographical Society. The coincidence of these lines, which, moreover, agreed with the general trends of the coal measures, was sufficiently striking, and Dr. Preller thought he might claim to have been the first to point it out on this occasion. He wished it to be understood that this coincidence applied, not necessarily to the path of all thunderstorms, which was determined by various other causes, but to the prevalence of lightning discharges along the two lines he had indicated.

Mr. J. BARTLETT said that when investigating the damage done to the trees at Bramley, he was much struck by the isolation of the area, no other damage appearing to have been done in the neighbourhood. As a result of a letter inserted in the local paper asking for information concerning any damage at other places, he had received but one reply, from a gentleman at Sutton Green, Worplesdon, 8 miles north-west of Bramley, from which it appeared that a cart shed and barn were partially destroyed and some trees blown down at that spot.

Dr. A. BUCHAN said that he was in Clarendon Street, Pimlico, when the storm and squall discussed by Mr. Marriott occurred, and he believed that the interval between the thunder and lightning was less than one second. The darkness was intense, although the lower air stratum was clear, as windows opposite were distictly seen, but the roof of a three-story house was barely discernible. He had noticed in Edinburgh when a change of wind was coming on that darkness gathered in a certain part of the sky, which assumed a tawny hue, while the opposite portion of sky was clear and of an opalescent appearance. The thunderstorm and squall of January 23rd belonged, he believed, to the type of atmospheric disturbance which the Americans designate by the term "tornado." The whole phenomenon appeared to be due to the meeting of two air currents of different temperature and humidity.

Mr. F. C. BAYARD inquired if it was correct to assume that a thunderstorm was to be always expected on the right-hand side of the track of an area of low pressure.

Dr. A. BUCHAN remarked that the satellite cyclone in which the thunderstorm is bound up is always on the right-hand side, and most generally to the south-south-eastwards of the main cyclone.

Mr. G. J. SYMONS said, that he believed that Northamptonshire was a county where lightning discharges were frequent: Oundle church had been repeatedly struck. The counties of Devon and Cornwall were generally exempt from damage by lightning, and he was inclined to think that the nature of the soil played some part in locating the areas of injury. The short time interval between the lightning and thunder in the storm of January 23rd was very remarkable, and appeared to be a particular feature of winter thunderstorms. At Camden Square the observations showed that the lightning discharges took place within half a mile, and the storm must therefore have been quite low in the atmosphere. He believed that winter thunderstorms were proportionately more destructive than those which occur in summer.

Mr. H. S. WALLIS said that he had been struck by the fact that nearly everyone who described the storm spoke of the nearness of the lightning. At Camden Square only five flashes were seen and five peals of thunder heard, and the time interval showed them all to be within a distance of about a mile; he understood Dr. Buchan to say that he, at Westminster, saw only three flashes, all of which he estimated to be within a mile of him. It was therefore

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evident that the flashes seen at Camden Square were invisible to Dr. Buchan, and the flashes seen at Westminster invisible and inaudible at Camden Square. It would appear that in this storm lightning could not be seen or thunder heard at a distance much exceeding a mile; and he thought that the two strata of air of very different temperature and humidity, mentioned by Dr. Buchan as causing the darkness, would account for this.

Mr. H. S. EATON remarked that he was in Kensington when the storm occurred, and noticed that its arrival was preceded by the appearance of cumulo-stratus clouds such as are associated with summer thunderstorms.

Mr. W. MARRIOTT, in reply, said that thunderstorms travelled with the wind along the isobaric lines. In the case of the storm of January 23rd the area of low pressure was in the east, and the thunderstorm travelled down the western side of it, following the direction of the isobars. He was not aware of any relation between the distribution of thunderstorms and the lines of terrestrial magnetism. Thunderstorm disturbances were regulated by the distribution of atmospheric pressure, and were most frequent over low-lying districts, often following the course of river valleys. The short time interval between the thunder and lightning, which was so noticeable a feature of the storm of January 23rd, was due to its low altitude in the atmosphere. Air temperature was also low, so the storm would not require to be very high in the atmosphere to give the decrement of temperature necessary for the formation of the hail which fell; summer thunderstorms were usually of greater altitude. He believed with Dr. Buchan that this thunderstorm was of the tornado type, and the sudden outburst of wind accompanying it appeared to support that view.

ON SOME GRADUAL WEATHER CHANGES IN CERTAIN MONTHS AT GREENWICH AND GENEVA.

BY ALEX. B. MACDOWALL, M.A., F.R.Met.Soc.

(Plate 2.)

[Received December 5th, 1894.—Read February 20th, 1895.]

THE variations, from year to year in a long series, of a given meteorological element, say, temperature, of the year or a part of it, are seldom long in the same direction (increase or decrease), and the curve representing such changes exhibits many zigzags. We may perceive, here and there, a distinct preponderance of higher values, and at other points of lower; and may accordingly picture to ourselves a series of longer waves, like an ocean swell which may be more or less obscured by the minor waves and ripples. Such longer waves may be rendered more evident by methods of smoothing or averaging; a curve being drawn in which each year point represents, not the actual value for that year, but the average of 3, or 5, or 7, or other number of yearly values.

It seems to me that a systematic investigation of the weather data of each month in this way, so as to bring into prominence the longer waves of variation, is calculated to yield many interesting results. Having done a

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good deal of work of this kind, I have thought the following examples (of method and results) might be not without interest to the Society.

The features of weather considered are temperature, frost days, and rain days. It seemed desirable to make a comparison of Greenwich with some other European station, and I have selected Geneva; using the excellent record of the Observatory there, as communicated annually to the *Archives des Sciences*, along with M. Plantamour's *Nouvelles Etudes*, which summarise the figures from 1826 to 1875. For frost days at Greenwich I have utilised a table by Mr. C. Harding in the *Quarterly Journal* (1891, p. 113).

A considerable amount of similarity is usually found between corresponding smooth curves for Greenwich and Geneva, though either set presents, of course, some distinctive features.

We may begin with the temperature variations of *February*. The numbers of frost days in February at Greenwich since 1842, having been smoothed by means of averages of five, we obtain the dotted line curve in the first diagram[1] (Plate 2). The same smoothing process has been applied to those averages, giving the continuous curve. These curves are *inverted*, the lower parts representing the higher values.

Taking the twice smoothed curve (as we may call it) we note three long waves, culminating in 1850, in 1869 (19 years' interval), and in 1882 13 years), mild Februaries preponderating at those points; while the lowest points are at 1855, 1874 (19 years), and in 1888 (14 years), cold Februaries preponderating.

Below are shown twice smoothed curves (alone) of frost days and mean temperature in February at Geneva since 1826 (the former curve being inverted). Here the recurrence of the same phases becomes somewhat more regular; the wave crests (at 1834, 1849, 1867, & 1883) showing an average interval of 16·3 years.

It is rather apart from my object in these remarks to suggest the existence of cycles; I have wished merely to present a picture of the actual variations in a given time. Nevertheless, this regularity may be pointed out as interesting.

The maxima and minima values of the 5-average in the case of Greenwich frost days may here be given.

The highest are as follows (in order of years):

1845.	1856.	1875.	1888.
14·4	14·4	18·2	16·6

and the lowest:

1850.	1869.	1883.
6·6	5·4	5·8

The range is thus between 5·4 in 1869 and 16·6 in 1888 (difference 11·2).

The case of *January* is presented in Fig. 2. The upper curve is a twice smoothed one of mean temperature at Geneva, while the second gives frost

[1] The vertical scale in these diagrams is varied according to convenience. Small letters (a, b, c,) indicate the vertical scale of each curve.

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days at Greenwich (inverted); both the once-smoothed curve (dotted line) and the twice smoothed (continuous line).

Two features may here be noted: first, a curious recurrence in both curves at about 10 years interval (on an average). The Geneva curve has wave crests in 1835, 1843, 1853, 1866, 1875, and 1884; and the waves of the Greenwich curve are in fair agreement as to phase, while differing from each other in magnitude (low minima alternating, in the period considered, with high ones). Secondly, a gradual rise and fall in the Geneva curve, suggestive of a much longer wave, of which those 67 years apparently present only a part.

The variation of the 5-average for Greenwich is from 7·8 (in 1858) and 7·6 (in 1874) to 16·4 (in 1848), and 17·4 (in 1880), extreme difference 9·8.

Let us now turn to consider the cold of *November*. A pair of inverted curves is given in Fig. 8, made from the number of frost days in that month since 1841; the dotted line curve, as before, from a first smoothing (with 5-averages), and the continuous curve from a second. These seem to indicate a change of character in November. Since about 1860 it has on the whole become milder. Thus the 5-average of frost days in that year was 9·6. It has never been so high since, and in 1890 it was only 3·8. Curves of mean temperature give a corresponding result.

The Geneva curve of frost days (not given) also shows a fall, but of shorter extent.

These facts have, I think, a bearing on the subject of fog, which is known to be closely related to temperature. The statistics we have of fogs may be said to be somewhat 'foggy,' owing, it would seem, to some uncertainty as to what should be called a fog. We used to hear a good deal about November fogs, as if that month were the worst offender. This notion, however, appears to be exploded. According to Scott, Symons, and Brodie, who have each discussed the subject in recent years, November takes a place after December, January, and even October. Now Symons and Brodie deal with 20 years (from 1871), and Scott with 15 years (from 1876); and I would here submit that if we went a little further back than 1871 we should probably find a larger number of fogs in November, corresponding to the greater cold. Some time ago I went through the *Registrar General's Weekly Return* from 1858 to 1888, noting the cases in which fog was mentioned in the weather tables; and the result gave November the highest place, though December came very close to it. And in the first half of that period of 31 years, the number of fog days was considerably greater (more than a third) than in the second half. Even if such an improvement in November has really taken place, I am afraid it would be vain to count on its permanency.

Another topic I propose to consider is, the number of *rain days* in the three months, *May*, *July* and *November*. The method here adopted is different, the figures being all smoothed with averages of 9.[1] On one side

[1] It may be stated that the method of twice smoothing with averages of 5 gives curves having in general the same features.

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of Fig. 4 is shown the result in the case of Greenwich (from 1815), and on the other in the case of Geneva (from 1826).

There are some curious relations between these curves, to which attention is invited. And first, it is interesting, I think, to find these three Greenwich curves resembling each other so much. Thus, a low point is reached in each, about the end of the twenties or beginning of the next decade, then there is a rise to high values in the fifties; another minimum is reached in the sixties, and there is a general rise since. Further, it may be noted that two of the Geneva curves, May and July, have features similar to those just described, indicating that the influence to which such changes are due is not of a purely local character.

Again, the November curve, for Geneva, diverges from the common type, and presents evident differences from the November curve for Greenwich. Thus, the maximum of 1852, in the latter, is unrepresented; and from a minimum in 1847 there is, one may say, a long gradual rise throughout the remainder of the period.

Of the three months, July and November show the closer similarity in Greenwich; while May and July are more like each other in the case of Geneva. At Greenwich the number of rain days in November has risen since 1860 along with the temperature. Once more, the intervals appear to suggest Brückner's 35 years period. According to his view, 1815, 1850, and 1880 are approximately centres of cold and wet periods, while 1830 and 1860 are centres of warm and dry periods.

I will conclude with two well-marked examples of long gradual changes in the character of months. One is that of the mean temperature of July in Geneva; the other the mean temperature of April at both stations.

The July mean temperature curve for Geneva (in which the actual values are simply smoothed with averages of 5) is given in Fig. 5. Note the long gradual ascent from a value of 62°·2 in 1842 to one of 68°·9 in 1872. The corresponding curve for Greenwich (dotted line curve, with distinct scale) is somewhat different, with a low point reached in 1862.

With regard to April (Fig. 6), it will be observed that long changes of rise and fall have been in progress. For example, the Greenwich curve falls with little interruption from 51°·0 in 1867 to 46°·0 in 1890;[1] that of Geneva from 51°·2 in 1864 to 46°·6 in 1890.

Some interesting questions seem to arise out of the facts that have been presented.

One is as to the extent of the earth's surface over which those and other changes may be observed. Are they traceable over the whole of Europe, and on other Continents? A knowledge of their extent might materially affect our ideas on another question, that viz. as to their cause or causes. Why should our weather at a particular part of the year become in a long series of years gradually colder, wetter, &c.? The 35 years' period

[1] The values of mean temperature here used are those given in a recent table by Dr. Buchan in the Scottish Meteorological Society's *Journal* (3 Ser. No. 9).

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(with which I have supposed some of those changes to be possibly connected), has been comprehensively studied by Brückner; but he does not appear to have obtained any light as to its causation.

Finally, it may fairly, I think, be considered whether those changes in the past do not afford some clues as to the future (in a general way). From a regular recurrence like that of Geneva frost days in February, might not a 'working hypothesis' be formed as to approaching waves of cold? The position now attained by such a curve as that of the November rain days seems to warrant us in expecting an early descent of the curve, &c.

To these, among other problems, I venture to invite the Society's attention.

REPORT ON THE

PHENOLOGICAL OBSERVATIONS FOR 1894.

By EDWARD MAWLEY, F.R.Met.Soc., F.R.H.S.

[Read February 20th, 1895.]

Returns were received from 113 observers in 1894, or from four less than in the previous year. The distribution of the observing stations has however, somewhat improved, as there are now four observers in Ireland South instead of two, nine in Ireland North instead of six, and eight in England North-east instead of seven. For the new observers in Ireland the Society is indebted to the courtesy of the Editor of the *Irish Naturalist*, who inserted a letter from me in that Journal asking for new observers, with an editorial footnote requesting his readers to comply with my request.

The changes in the observing stations since the last Report was issued have been as follows:—No returns were sent in from Liskeard and West Bagborough in District **A.**; Wicklow in District **B.**; Bidborough, Lynsted, Bickley, Willinghurst, Croydon, Farley and Salisbury in District **C.**; Broxbourne, Walsall, Eaton and Bakewell in District **D.**; Wryde in District **E.**; Heswell in District **F.**; and Driffield in District **L.** On the other hand new stations have been started at Barnstaple in District **A.**; Ferns, Woodenbridge and Greystones in District **B.**; Whitchurch Canonicorum and Bere Regis in District **C.**; Hatfield in District **E.**; Ellesmere in District **F.**; Westport, Ballymena and Ramelton in District **G.**; and Great Cotes and Lilliesleaf in District **I.**

Most of the districts into which the British Isles are divided are moderately well represented, but new observers are still very much wanted in Ireland South and Scotland North and East.

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At most of the stations the observations seem to have been made with considerable care, and in many cases the observers appear to take a keen interest in their work and endeavour to make their returns as complete and satisfactory as possible. Of the present staff about three-fourths of their number have sent in returns throughout the four years that the present system of observations has been adopted—most of these having from the commencement been among the Society's most trustworthy observers.

Table I. will show how satisfactory, on the whole, have been the returns sent in during the four years.

TABLE I.—MEAN RESULTS, WITH THEIR VARIATIONS FROM THE ADOPTED AVERAGE, FOR THE 13 PLANTS IN ALL THE DISTRICTS WHERE THERE HAVE BEEN SUFFICIENT OBSERVERS TO WARRANT COMPARISONS BEING MADE.

Years.	Eng. SW.		England, S.		Eng. Mid.		England, E.		Eng. NW.	
	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.
		Days.		Days.		Days.		Days.		Days.
1891	144	+13	144	+11	150	+14	147	+11	150	+13
1892	139	+ 8	138	+ 5	144	+ 8	143	+ 7	147	+10
1893	118	—13	122	—11	125	—11	123	—13	128	— 9
1894	126	— 5	130	— 3	135	— 1	127	— 9	137	Av.

The Winter of 1893-4.

December was a mild winter month in all the districts, the departures from the average in mean temperature ranging from +1°·8 in England South to +4°·0 in Scotland West and East. The first week or ten days in January proved very cold, especially in the Midlands, Ireland North, and Scotland East, but after this time unseasonably warm weather prevailed until the end of the month. With the exception of one week towards its close, when moderate frosts were experienced in most districts, the February temperatures were uniformly high. Taking the quarter as a whole the fall of rain in many parts of the British Isles was more or less in excess of the average. The record of sunshine, at all but the Scotch stations, also exceeded the mean.

The winter of 1893-4 was entered upon by farm and garden crops under very favourable circumstances. The soil, owing to the beneficial effects of the warm and dry summer of 1893 and the scanty vegetation of that year, was in a very fertile condition. The autumn sown cereals were sturdy and well-rooted, and thus well fitted to withstand any severe weather they might be called upon to encounter during the next three or four months. Fruit and other flowering trees and shrubs were furnished with exceptionally well ripened shoots, but on dry soils were in many cases still feeling the effects of the recent droughts. Early in January there occurred a brief but very keen frost, which appears to have been most severely felt in parts of Ireland and Scotland, where in many places evergreen shrubs were much crippled, and in some instances killed outright. In the neighbourhood

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of Cork large areas of broccoli, growing in the market gardens, were completely destroyed. In the north Midlands also this frost, being preceded by cutting North-easterly winds, did much damage to shrubs and vegetables. But taking the country generally, little permanent harm was done to vegetation by this short spell of cold weather. No sooner was it at an end than a return to milder conditions took place, and although another cold week occurred in February the crops generally continued to make steady progress during the remainder of the season.

The hazel came into flower rather earlier than usual in the southern half of the Kingdom, but was late in the northern counties of England and in the west of Scotland. The flowering of the coltsfoot was also backward in the north, but about average in the warmer districts.

The song-thrush was heard at earlier dates than in either of the three previous years. The honey-bee first visited flowers at about the same time as in 1891 and 1893, but decidedly earlier than in 1892.

The Spring.

Throughout the whole of the British Isles both March and April were very warm months, but during May the weather became colder, and at the end of the third week there occurred on two successive nights frosts of exceptional severity for so late in the spring. March and April taken together had a deficient rainfall in all but the Irish districts, whereas in May the total fall was almost everywhere rather in excess of the mean. The first spring month proved in all parts one of brilliant sunshine, while April was also more sunny than usual; but during May, with the exception of Scotland East and North, where the weather continued bright, there was a deficiency of clear sunshine.

Farmers were enabled to work their land and prepare it for spring corn and roots under very favourable conditions, as the soil remained not only dry and friable, but also during a great part of the season unusually warm. The autumn sown cereals and grass also made good growth. In the gardens, until after the middle of May, the prospect of an exceptionally bountiful crop of fruit never perhaps before appeared so certain of realisation; for the trees and bushes were not only provided with young wood splendidly matured, but were heavily laden with fine healthy blossoms.

Unfortunately, on May 21st and 22nd there occurred two severe frosts, followed by keen North-easterly winds, which at once changed these brilliant prospects. The havoc committed among the fruit blossoms appears to have been very general, apples and strawberries being the greatest sufferers. No district entirely escaped this frost, and this was perhaps the most remarkable feature of it. Then again, although visiting nearly all parts of the kingdom, it is surprising how greatly the injuries resulting from it varied even within short distances, and how some localities were altogether untouched by it. Beyond giving a temporary check to their growth, this winterly weather did but little injury to the corn and grass. Potatoes, however, suffered severely in all parts of the country, and in the localities most

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seriously affected beans, peas, and turnips and other like crops were also injured; while the oaks, ashes, horsechestnuts, and other trees had their young foliage entirely destroyed. By some observers the principal damage done to foliage and blossoms is attributed to the wind, while others say that it only affected trees, &c. situated in low-lying positions. Others again attribute it to the leaves and flowers being wet on one of the frosty nights, and some to the sun shining upon them when in a frozen condition. No doubt in many cases it was not the degree of cold alone, but one or more of the above influences combined with it, which caused the damage done to be greater than it otherwise would have been. Besides which, the cold winds which followed the frost must have greatly increased the injuries it inflicted. Taking the means of all the extreme minima at the Meteorological Office stations for the different districts during the May frost, and beginning with those which come out with lowest temperatures, they arrange themselves as follows:—Scotland East (J.), Scotland North (K.), England Midlands (D.), Scotland West (H.), England North-east (I.), Ireland North (G.), England East (E.), England North-west (F.), England South-west (A.), Ireland South (B.), and England South (C.); the means ranging from 28°·5 in Scotland East to 34°·6 in England South.

The wood anemone came into blossom from ten days to three weeks late. But the flowering of all the spring plants after this, until the third week in May, took place decidedly early, and in some cases earlier even than in 1893. For instance, the blackthorn was in bloom from a week to ten days in advance of the mean in most parts of the country; garlic hedge mustard ten days to a fortnight, and the horsechestnut and hawthorn from a fortnight to three weeks earlier than usual; whereas the white ox-eye, which flowered after the middle of May and in the beginning of June, varied from about average to less than a week early in the first six districts, and was from a week to three weeks late in the more northern ones.

The spring migrants made their appearance in this country as a rule in advance of their usual time:—The swallow at an earlier date than in either of the three preceding years, except 1893; the cuckoo four days earlier than in the previous spring, and nearly a fortnight earlier than in either 1891 or 1892. The dates for the nightingale and flycatcher are also very early ones.

As in 1893, wasps and the small white butterfly were first seen unusually early in the year, but the orange tip butterfly, although also early, made its appearance somewhat later than in the previous year.

The Summer.

With the exception of the last week June was a cold summer month. July began with a hot week, and there was a little warm weather at its close, but during the rest of the month the temperature remained below the average, while August proved cold throughout. Taking the summer as a whole, the temperature was below the average in every district except Scotland North, where the July mean compared with average comes out as +2°·8. In nearly all parts of the Kingdom the summer was a wet one,

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TABLE II.—LIST OF OBSERVERS.

	Station.	County.	Height above sea-level.	Observer.
	A.		Ft.	
1	Marazion	Cornwall	40	F. W. Millett
2	Mawnan Smith	Cornwall	200	Miss R. Barclay
3	Falmouth	Cornwall	190	Miss Willmore
4	Tiverton	Devon	270	Miss M. E. Gill
5	Westward Ho	Devon	100	H. A. Evans
6	Instow	Devon	250	H. M. W. Hinchliff
7	Barnstaple	Devon	20	T. Wainwright
8	Sidcot	Somerset	200	W. F. Miller C. B. Rowntree
9	Long Ashton	Gloucester	280	Miss H. Dawe
10	Clifton	Gloucester	300	G. C. Griffiths, F.E.S.
11	Penarth	Glamorgan	120	G. A. Birkenhead
12	Cardiff	Glamorgan	40	A. Pettigrew
13	Castleton	Glamorgan	80	F. G. Evans, F.R.Met.Soc.
14	Bassaleg	Monmouth	25	W. J. Grant
15	St. Arvan's	Monmouth	360	Miss M. Peake
16	St. David's	Pembroke	220	W. P. Propert, LL.D., F.R.Met.Soc.
17	Aberystwith	Cardigan	30	J. H. Salter, B.Sc.
	B.			
18	Killarney	Kerry	100	Ven. Archdeacon Wynne
19	Ferns	Wexford	260	G. E. J. Greene, D.D., F.L.S.
20	Woodenbridge	Wicklow	300	J. Hunter
21	Greystones	Wicklow	20	Mrs. W. Wynne
	C.			
22	Bembridge	Isle of Wight	80	C. Orchard
23	Whitchurch, Canonicorum	Dorset	150	Miss Mules
24	Bere Regis	Dorset	130	W. Bedford
25	Blandford	Dorset	270	J. C. Mansell-Pleydell, F.G.S., F.L.S.
26	Buckhorn Weston	Dorset	290	Miss H. K. H. D'Aeth
27	Pennington	Hants	100	Miss E. S. Lomer
28	Strathfield Turgiss	Hants	200	Rev. C. H. Griffith
29	Bexhill-on-Sea	Sussex	10	H. Le M. Dunn
30	Muntham	Sussex	250	P. S. Godman, F.Z.S.
31	Dover	Kent	150	F. D. Campbell
32	Farnborough	Kent	350	F. G. M. Kelly
33	Swanley	Kent	220	C. H. Hooper
34	Chislehurst	Kent	360	Miss F. Duncan
35	Coneyhurst	Surrey	600	J. Russell
36	Churt Vicarage	Surrey	350	Rev. A. W. Watson
36	Churt	Surrey	300	C. Criddle
37	Cranleigh	Surrey	180	Admiral J. P. Maclear, F.R.Met.Soc.
38	Winterfold	Surrey	580	R. Turvey
39	Oxshott	Surrey	210	W. H. Dines, B.A., F.R.Met.Soc.
40	Ashtead	Surrey	..	R. M. Prideaux
41	Addlestone	Surrey	100	C. U. Tripp, M.A., F.R.Met.Soc.
42	East Molesey	Surrey	40	Lady Jenkyns
43	Marlborough	Wilts	480	E. Meyrick
44	Whatley	Somerset	450	C. G. Whittaker
45	Whitchurch	Oxford	150	Rev. J. Slatter, M.A., F.R.Met.Soc.
46	Reading	Berks	..	H. Goadby
	D.			
47	Oxford	Oxford	200	F. A. Bellamy, F.R.Met.Soc.
48	Cheltenham	Gloucester	250	M. L. Evans
49	Beckford	Gloucester	120	F. Slade, F.R.Met.Soc.
50	Watford	Herts	240	Mrs. G. E. Bishop
51	St. Albans (The Grange)	Herts	380	Mrs. Hopkinson

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TABLE II.—LIST OF OBSERVERS—*Continued.*

Station.	County.	Height above sea-level.	Observer.
D.		Ft.	
51 St. Albans (Addiscombe Ldg.)	Herts	400	Miss E. F. Smith
51 St. Albans (Worley Road)	Herts	300	H. Lewis
51 Radlett	Herts	320	Miss E. M. Lubbock
52 Berkhamsted	Herts	400	Mrs. E. Mawley
53 Harpenden	Herts	370	J. J. Willis
54 Ross	Hereford	210	H. Southall, F.R.Met.Soc.
55 Breinton	Hereford	230	H. A. Wadworth, F.R.G.S.
56 Evesham	Worcester	120	Rev. D. Davis, B.A.
57 Henley-in-Arden	Warwick	320	T. H. G. Newton, F.R.Met.Soc.
58 Northampton	Northampton	320	H. N. Dixon, M.A., F.L.S.
59 Churchstoke	Montgomery	550	P. Wright, F.R.Met.Soc.
60 Burbage	Leicester	430	C. C. Hurst, F.R.H.S.
61 Thurcaston	Leicester	250	Rev. T. A. Preston, F.R.Met.Soc.
62 Uppingham	Rutland	300	G. W. S. Howson, M.A.
63 Tean	Stafford	470	Rev. G. T. Ryves, F.R.Met.Soc. Miss M. G. B. Ryves
64 Beeston	Notts	210	G. Fellows, F.R.Met.Soc.
65 Hodsock	Notts	60	Miss Mellish, F.R.H.S.
66 Macclesfield	Cheshire	500	J. Dale
67 Belton	Lincoln	200	Miss F. H. Woolward
68 Harrogate	Yorkshire	340	J. Farrah, F.R.Met.Soc.
E.			
69 Hatfield	Herts	..	T. Brown
70 Hertford	Herts	140	W. Graveson
71 Hitchin	Herts	230	J. E. Little, M.A.
72 Ashwell	Cambridge	260	H. G. Fordham
73 Bocking	Essex	240	H. S. Tabor, F.R.Met.Soc.
74 Lexden	Essex	90	Miss Carver
75 Sproughton	Suffolk	30	Rev. A. Foster-Melliar
76 Tacolneston	Norfolk	190	Miss E. J. Barrow
F.			
77 Ellesmere	Shropshire	300	J. A. S. Jennings
78 Penmaenmawr	Carnarvon	350	A. T. Johnson
79 Claughton	Lancashire	80	Mrs. K. Green
80 Giggleswick	Yorkshire	500	E. Peake, M.A.
81 Ambleside	Westmoreland	320	S. A. Marshall
82 Egremont	Cumberland	160	J. Sherwen
83 Cronkbourne	Isle of Man	110	A. W. Moore J. Murphy
84 Orry's Dale	Isle of Man	70	Miss C. G. Crellin
85 Sulby	Isle of Man	80	H. S. Clarke, F.E.S.
G.			
86 Edgeworthstown	Longford	270	J. M. Wilson, B.A.
87 Westport	Mayo	10	J. M. McBride
88 Loughbrickland	Down	350	Rev. H. W. Lett, M.A.
89 Saintfield	Down	310	Rev. C. H. Waddell, M.A.
90 Antrim	Antrim	70	Rev. W. S. Smith
91 Ballymena	Antrim	150	W. Anderson
92 Londonderry	Londonderry	450	T. Gibson
93 Ballynagard	Londonderry	30	Miss A. M. Campbell
94 Ramelton	Donegal	200	Miss K. Swiney
H.			
95 Dalshangan	Kirkcudbright	500	T. R. Bruce
96 Tynron	Dumfries	520	J. Shaw
97 Thornhill	Dumfries	300	J. Fingland
98 Jardington	Dumfries	100	J. Rutherford
99 Helensburgh	Dumbarton	100	Miss Muirhead

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TABLE II.—LIST OF OBSERVERS—*Continued.*

Station.	County.	Height above sea-level.	Authority.
		Ft.	
I.			
100 Doddington	Lincoln	90	Rev. R. E. Cole
101 Great Cotes	Lincoln	..	J. Cordeaux
102 Thirsk	Yorks (N. R.)	120	A. B. Hall
103 East Layton	Yorks (N. R.)	570	Mrs. E. O. Maynard Proud
104 Durham	Durham	350	H. J. Carpenter
105 Low Fell	Durham	90	A. W. Price
106 Cambois	Northumberland	20	S. Dunnett
107 Lilliesleaf	Roxburgh	530	Miss O. R. Carre
J.			
108 Aberdeen	Aberdeen	40	P. Harper
K.			
109 Inverbroom	Ross	50	J. A. Fowler

The numbers before the names of the Stations refer to their position on the map of the Stations (Fig. 1, p. 119).

while there was everywhere a marked deficiency of bright sunshine, except in the north of Scotland, where the weather appears to have been remarkably sunny.

In the earlier districts most of the hay was harvested in splendid condition, and as was the case everywhere, the crop proved an unusually heavy one; but in the later districts rain greatly interfered with its ingathering. The corn made slow but satisfactory progress until warmer weather set in for a time at the end of June, after which it grew more rapidly and very strongly. Much of this fine crop was, however, beaten down by the heavy thunderstorms of July and August. The corn harvest was a very long and tedious one, owing to the many interruptions caused by the frequent rains.

Weeds, as might have been expected in such a cool wet summer, grew apace, and were with difficulty kept under. Slugs and snails were unusually numerous and destructive. But the pests of the season were undoubtedly aphides of all kinds, which did considerable mischief to fruit and other trees, roses, &c. Earwigs were also very numerous in East Anglia and other parts. There were, however, very few wasps or butterflies anywhere to be seen.

Owing to the May frosts there was almost everywhere a very scanty crop of strawberries. Raspberries, currants and gooseberries also yielded badly, especially in the midland and northern counties of England and in Scotland.

The dog-rose flowered at about its average date in all the first six districts except England East, where it was early, but was decidedly late in most of the northern districts. The flowering of the black knapweed, the harebell and the greater bindweed was very irregular, but in the case of the two last named was in most parts of the country rather in advance of the mean.

The meadow brown butterfly made its appearance later than in any year since 1891.

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The Autumn.

Septemb r proved everywhere a cold month, but in October there were a good many moderately warm days, and during November the weather remained throughout unseasonably mild in all parts of the country. The

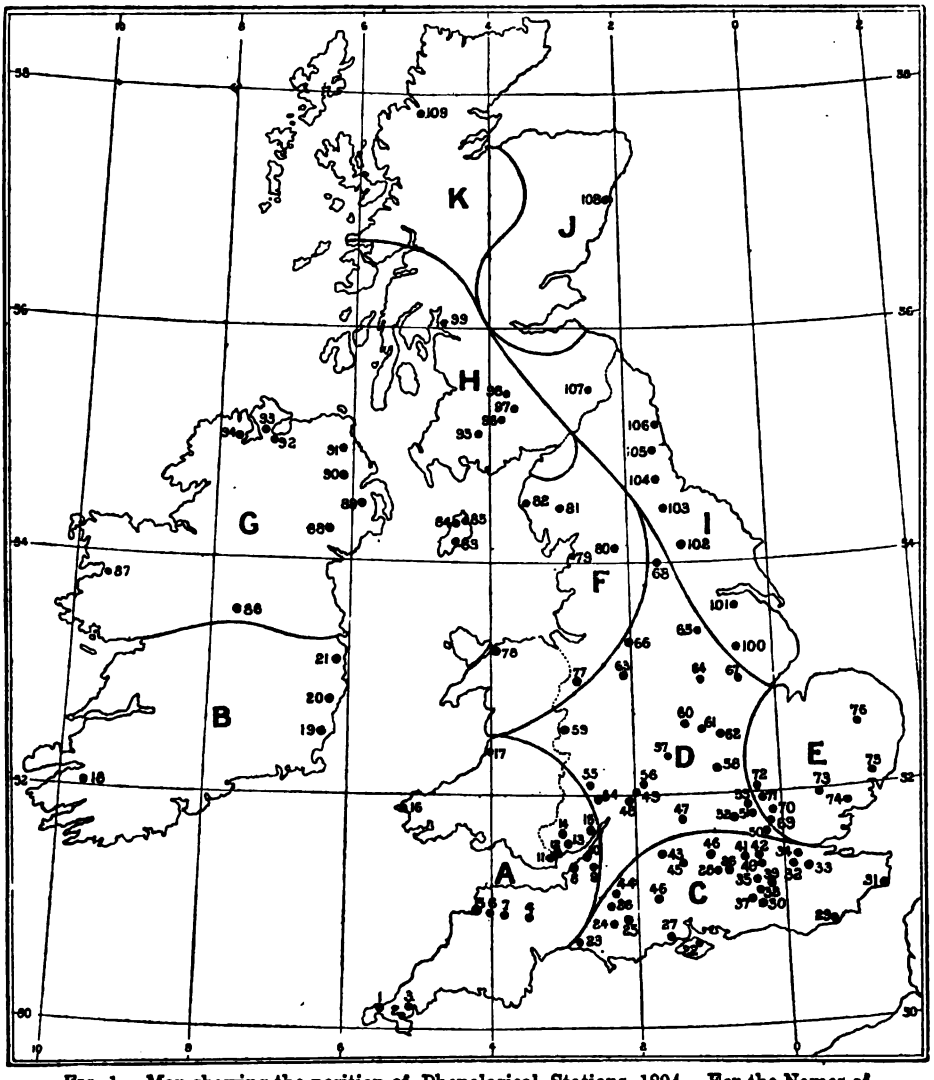

FIG. 1.—Map showing the position of Phenological Stations, 1894. For the Names of the Stations, see List of Observers, Table II.

total rainfall of this quarter was large in the South and South-west of England, but by far the greater part of it was deposited during the three weeks ending November 14th, which were excessively wet. In most of the other districts the fall varied from about average to over 4 inches in

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TABLE III.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1894.

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse Chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
A.													
Marazion	30	34	..	63	..	114	109	*160*	141	192	..	196	267
Mawnan Smith	20	..	83	62	..	110	117	141	160	..	..	..	267
Falmouth	34	47	..	57	..	101	102	147	..	..	..	..	..
Tiverton	27	44	82	81	95	111	110	135	144	158	..	..	..
Westward Ho	..	46	..	..	92	..	..	..	..	186	..	..	..
Instow	..	..	82	82	98	105	100	..	..	..	..	..	..
Barnstaple	28	51	75	71	89	105	113	140	154	170	..	169	277
Sidcot	1	34	62	85	94	99	116	138	149	..	..	186	252
Long Ashton	..	..	..	..	..	113	121	..	161	..	168	..	289
Clifton	..	..	82	90	..	103	111	..	..	..	..	..	270
Cardiff	22	40	..	84	..	101	110	..	158	..	..	201	274
Castleton	41	34	72	76	94	96	113	125	146	183	200	192	260
Bassaleg	20	52	86	83	..	96	106	139	160	..	..	181	268
St. Arvans	30	..	81	89	101	108	122	144	..	179	203	199	263
St. David's	..	64	..	77	..	..	..	..	..	..	..	203	..
Aberystwith	20	55	77	..	89	104	105	122	132	164	..	164	263
B.													
Killarney	14	46	67	50	101	93	98	130	150	200	..	191	244
Ferns	..	..	61	79	*146*	106	115	142	151	..	..	155	..
Woodenbridge	..	..	..	..	..	111	118	124	165	..	..	208	268
Greystones	..	35	..	69	..	107	117	..	..	..	..	..	..
C.													
Bembridge	26	20	..	86	98	109	109	127	..	..	..	..	..
Whitchurch, Canonicorum	21	39	66	79	94	115	106	125	153	160	..	196	..
Blandford	17	61	78	78	..	115	125	135	..	191	175	201	301
Buckhorn Weston	22	51	75	85	94	111	106	132	150	165	..	181	276
Pennington	23	62	..	85	100	102	121	124	154	159	159	..	280
Strathfield Turgiss	32	51	70	87	95	109	112	135	155	169	160	175	255
Bexhill-on-Sea	41	..	71	90	105	107	102	130	139	..	..	..	293
Muntham	29	47	78	82	100	108	100	129	147	172	..	218	266
Dover	..	39	..	88	..	103	122	..	163	182	..	..	280
Farnborough	34	51	..	89	91	113	107	134	161	..	..	..	..
Chislehurst	21	58	84	83	110	111	116	136	156	..	195	171	285
Coneyhurst	..	..	79	88	111	120	118	130	150	..	196	202	283
Churt (Vicarage)	20	81	83	90	101	121	116	144	162	..	158	..	..
Churt	14	58	83	84	99	102	116	135	144	157	166	201	*234*
Cranleigh	29	..	75	83	97	103	106	142	154	166	..	188	285
Winterfold	29	33	..	..	..	118	128	145	150	*214*	197	..	276
Oxshott	39	..	82	89	103	118	110	..	162	..	..	..	..
Ashtead	41	56	..	94	103	116	129	151	147	196	..	..	..
Addlestone	31	79	98	90	99	104	112	142	155	180	192	195	..
East Molesey	35	61	..	88	106	106	115	..	159	175	..	204	269
Marlborough	20	39	69	76	101	120	118	142	151	174	188	..	262
Whatley	33	..	84	99	104	110	125	145	168	188	..	..	..
Whitchurch	21	..	..	..	..	..	..	..	..	..	..	..	..
Reading	44	71	90	77	..	..	..	..	..	..	..	..	..
D.													
Oxford	32	71	..	87	94	107	115	143	145	173	..	..	251
Cheltenham	26	62	70	82	103	110	117	152	155	..	200	209	251
Beckford	28	57	84	81	104	106	110	121	150	..	..	..	258
Watford	34	74	89	85	110	120	121	150	153	..	..	..	284
St. Albans (The Grange)	34	..	77	89	104	110	118	147	..	..	..	..	289
St. Albans (Ad. Lge.)	30	62	..	66	100	103	116	118	159	180	200	223	293
Radlett	38	..	..	88	110	108	121	..	..	..	..	..	..

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TABLE III.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1894—*Continued.*

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse Chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
D.													
Berkhamsted	39	58	89	89	99	116	*133*	152	150	187	201	187	289
Harpenden	30	60	..	87	102	113	115	126	154	..	..	.	..
Ross	42	42	..	..	103	107	103	..	..	..	..	..	..
Breinton	40	55	81	86	97	114	113	120	146	182	190	195	274
Evesham	37	61	*98*	86	..	..	102	131	152	*212*	..	177	289
Henley-in-Arden ..	*56*	48	83	88	*121*	110	118	..	152	..	..	..	..
Northampton	41	60	76	91	108	113	115	132	166	182	186	219	265
Churchstoke	45	70	80	86	103	117	125	143	168	192	194	200	301
Burbage	29	44	84	96	..	118	120	..	*181*	..	..	..	..
Thurcaston	38	39	90	89	103	119	115	159	159	177	..	222	..
Uppingham	44	62	79	96	109	116	115	132	152	..	195	..	..
Tean	31	87	..	93	..	..	128	163	..	..	188	..	..
Beeston	31	66	..	87	..	121	119	156	170	176	175	..	..
Hodsock	13	37	87	85	104	112	122	156	169	187	192	187	273
Macclesfield	38	65	85	99	..	115	116	160	165	187	188	196	274
Belton	23	58	72	87	112	..	116	143	168	183	203	209	..
Harrogate	−1	55	84	90	106	122	*141*	165	174	186	188	192	308
E.													
Hatfield	..	..	88	86	..	104	111	..	150	..	..	..	..
Hertford	18	39	70	67	95	110	102	130	144	161	193	191	259
Hitchin	34	35	76	79	98	103	103	131	140	168	179	193	271
Ashwell	19	58	..	83	..	115	110	..	..	..	..	..	..
Bocking	29	65	91	93	105	107	124	157	157	*210*	..	..	248
Lexden	34	..	74	91	101	101	114	..	148	..	..	..	266
Sproughton	30	..	..	..	104	113	115	135	151	..	..	..	291
F.													
Ellesmere	49	63	81	..	105	..	..	..	..	..	..	..	..
Penmaenmawr	..	*91*	83	82	..	109	106	*119*	162	179	199	200	263
Claughton	..	62	83	90	..	..	..	..	..	199	207	207	..
Giggleswick	26	68	83	93	110	120	133	148	159	187	185	188	..
Ambleside	20	79	91	95	..	..	..	..	..	..	..	..	..
Egremont	41	58	82	92	112	110	114	133	162	176	180	180	294
Cronkbourne	..	..	..	..	..	..	..	..	..	..	..	..	300
Orry's Dale	37	..	*127*	..	..	*136*	136	..	..	..	..	..	301
G.													
Edgeworthstown ..	*73*	..	94	90	..	..	..	..	175	..	..	..	..
Westport	..	..	..	80	..	103	113	..	..	..	..	..	232
Loughbrickland ..	36	59	89	90	..	109	118	165	167	..	..	..	..
Saintfield	..	57	72	87	..	114	128	146	..	..	..	..	298
Antrim	37	64	66	88	97	116	127	157	..	202	..	222	..
Ballymena	..	..	..	..	..	125	131	153	178	..	205	191	..
Londonderry	57	71	86	98	..	112	127	138	171	212	..	..	..
Ballynagard	..	..	48	..	..	..	120	..	..	..	..	202	..
Ramelton	..	..	..	..	..	..	119	153	175	215	..	214	..
H.													
Dalshangan	39	82	..	96	..	..	..	..	..	..	..	..	..
Tynron	35	..	92	93	..	133	145	166	174	215	201	..	..
Thornhill	56	*94*	98	96	..	..	136	..	..	..	..	..	..
Jardington	42	76	85	98	..	124	130	..	171	204	193	..	..
Helensburgh....	42	77	95	105	119	122	132	160	173	..	..	193	249
I.													
Doddington	40	76	87	92	109	116	120	160	167	..	..	..	..
Thirsk	19	38	77	87	105	109	120	154	166	..	181	..	309
East Layton	*64*	72	103	100	..	120	145	*183*	185	196	201	195	315
Durham	48	55	91	*115*	..	136	143	..	185	..	207	..	..

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TABLE III.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1894—*Continued.*

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse Chestnut.	Hawthorn.	White Ox-eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
I.													
Low Fell	50	70	105	104	..	..	141	..	183	220	..	*243*	298
Cambois	49	53	96	97	..	*160*	139	163	171	..	182	201	272
Lilliesleaf	46	..	91	96	..	138	140	163	182	..	187	207	*332*
J.													
Aberdeen	..	82	103	..	..	..	..	173	178	..	..	..	..
K.													
Inverbroom	13	37	106	..	..	..	..	..	178	..	197	..	293

The dates in italics have not been taken into consideration when calculating the means given in Table IV. (p. 123).

Explanation of the dates in the Tables.

1– 31	are in January.	182–212	are in July.
32– 59	„ February.	213–243	„ August.
60– 90	„ March.	244–273	„ September.
91–120	„ April.	274–304	„ October.
121–151	„ May.	305–334	„ November.
152–181	„ June.	335–365	„ December.

Scotland. During September and October the record of sunshine was very variable, but November throughout the British Isles proved exceedingly bright.

The corn crops ripened very slowly in the later districts, but the finer weather in September and the early part of October allowed of this lingering harvest being at last brought to an end, at all events in all but the colder parts of Scotland. The yield of both straw and corn was unusually large, but, as stated by Sir John Lawes at the time, "the crops suffered from bad maturing and harvesting." The turnips and other roots made fair growth, and in many places there was an excellent second crop of grass. Indeed, until the end of the season the abundance of keep in the meadows was remarkable. Until the heavy rains set in at the end of October, the ploughing of the land and preparing it for the winter crops proceeded without interruption, but after that time wheat sowing was rendered in many places impracticable, owing to the saturated condition of the ground.

The yield of both wheat and barley, taking the country as a whole, was decidedly above the average, but the most remarkable cereal crop of the year was oats, which yielded the heaviest crop since official statistics were first collected in 1884. The harvest began in most districts from about a fortnight to nearly a month later than in 1893, but at earlier dates than in either 1891 or 1892. Taking the country generally the crop of beans and peas was about an average one. Early potatoes as a rule yielded badly owing to the May frosts; the later varieties were also under the average, and in many places much diseased. Both turnips and mangolds were unusually good crops.

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TABLE IV.—MEAN DATES (DAY OF YEAR) FOR THE FIRST FLOWERING OF PLANTS IN 1894, AND THEIR VARIATIONS FROM THE AVERAGE.

Plants.	1894.	Approximate Average.	Variation from Average.	1894.	Approximate Average.	Variation from Average.	1894.	Approximate Average.	Variation from Average.	1894.	Approximate Average.	Variation from Average.
	A. Eng. S.W.			B. Ireland, S.			C. Eng. S.			D. Eng. Mid.		
Hazel	23	23	Av.	14	21	— 7	28	31	— 3	32	35	— 3
Coltsfoot	46	44	+ 2	41	42	— 1	53	52	+ 1	59	56	+ 3
Wood Anemone	78	58	+20	64	56	+ 8	79	66	+13	82	70	+12
Blackthorn	77	91	—14	66	91	—25	86	91	— 5	87	93	— 6
Garlic Hedge Mustard	94	111	—17	101	111	—10	101	111	—10	104	113	— 9
Horse Chestnut	105	126	—21	104	126	—22	111	126	—15	113	128	—15
Hawthorn	111	131	—20	112	131	—19	115	131	—16	116	133	—17
White Ox Eye	137	139	— 2	132	139	— 7	136	139	— 3	143	141	+ 2
Dog Rose	151	156	— 5	155	160	— 5	154	155	— 1	158	158	Av.
Black Knapweed	176	175	+ 1	200	179	+21	174	174	Av.	183	177	+ 6
Harebell	190	189	+ 1	..	193	..	179	188	— 9	192	191	+ 1
Greater Bindweed	188	195	— 7	185	199	—14	194	194	Av.	201	197	+ 4
Ivy	268	263	+ 5	256	266	—10	278	270	+ 8	279	274	+ 5
Mean for the 13 Plants	126	131	— 5	119*	127*	—8*	130	133	— 3	135	136	— 1

Plants.	E. Eng. E.			F. Eng. N.W.			G. Ireland, N.			H. Scotland, W.		
Hazel	27	36	— 9	35	32	+ 3	43	29	+14	43	33	+10
Coltsfoot	49	57	— 8	66	53	+13	63	50	+13	78	54	+24
Wood Anemone	80	71	+ 9	84	67	+17	76	64	+12	93	68	+25
Blackthorn	83	95	—12	90	97	— 7	89	97	— 8	98	99	— 1
Garlic Hedge Mustard	101	115	—14	109	117	— 8	97	117	—20	119	119	Av.
Horse Chestnut	108	130	—22	113	132	—19	113	132	—19	126	134	— 8
Hawthorn	111	135	—24	122	137	—15	123	137	—14	136	139	— 3
White Ox Eye	138	143	— 5	141	145	— 4	152	145	+ 7	163	147	+16
Dog Rose	148	157	— 9	161	161	Av.	173	164	+ 9	173	164	+ 9
Black Knapweed	165	176	—11	185	180	+ 5	210	183	+27	210	183	+27
Harebell	186	190	— 4	193	194	— 1	205	197	+ 8	197	197	Av.
Greater Bindweed	192	196	— 4	194	200	— 6	207	203	+ 4	193	203	—10
Ivy	267	273	— 6	290	271	+19	265	271	— 6	249	273	—24
Mean for the 13 Plants	127	136	— 9	137	137	Av.	140	138	+ 2	144	139	+ 5

Plants.	I. Eng. N.E.			J. Scotland, E.			K. Scotland, N.			British Isles.		
Hazel	42	37	+ 5	..	38	..	13	37	—24	30	31	— 1
Coltsfoot	61	58	+ 3	82	59	+23	37	58	—21	58	53	+ 5
Wood Anemone	93	72	+21	103	73	+30	106	72	+34	85	67	+18
Blackthorn	99	102	— 3	..	103	..	..	110	..	86	95	— 9
Garlic Hedge Mustard	107	122	—15	..	123	..	..	130	..	104	115	—11
Horse Chestnut	124	137	—13	..	138	..	..	145	..	113	130	—17
Hawthorn	135	142	— 7	..	143	..	..	150	..	120	135	—15
White Ox Eye	160	150	+10	173	151	+22	..	158	..	147	144	+ 3
Dog Rose	177	163	+14	178	166	+12	178	173	+ 5	164	162	+ 2
Black Knapweed	208	182	+26	..	185	..	..	192	..	190	179	+11
Harebell	192	196	— 4	..	199	..	197	206	— 9	192	194	— 2
Greater Bindweed	201	202	— 1	..	205	..	..	212	..	195	199	— 4
Ivy	299	274	+25	..	277	..	293	276	+17	274	271	+ 3
Mean for the 13 Plants	146	141	+ 5	..	143	..	..	148	..	135	137	— 2

* For 12 Plants only.

\+ indicates the number of days later than the average date.

— " " " earlier " "

Av. " average date.

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TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1894.

Station.	Song.	Migration.					Insects.				
	Song Thrush First heard.	Swallow First seen.	Cuckoo First heard.	Nightingale First heard.	Flycatcher First seen.	Swallow Last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
A.											
Marazion	20	99	93	..	..	289	75	87	79	135	178
Mawnan Smith	..	112	..	..	103	..	75	..	77	121	173
Falmouth	..	113	..	..	..	..	45	103	..	..	..
Tiverton	..	118	103	..	..	..	..	..	..	..	..
Westward Ho	..	82	..	..	133	..	..	..	82	114	..
Instow	..	99	110	..	..	..	..	81	81	..	..
Barnstaple	21	..	..	..	..	..	..	..	..	..	..
Sidcot	..	94	91	126	130	287	..	..	..	115	110
Long Ashton	..	106	98	..	133	..	..	..	..	*152*	..
Clifton	..	..	103	..	..	..	..	..	84	111	176
Penarth	..	..	..	..	..	..	62	98	82	111	169
Cardiff	..	95	103	..	..	270	13	81	87	..	..
Castleton	12	101	96	..	140	284	70	82	101	103	127
Bassaleg	21	117	97	114	..	288	51	89	..	..	..
St. Arvan's	17	94	99	..	129	278	39	88	92	..	178
St. David's	39	107	107	..	..	284	51	..	*124*	..	..
Aberystwith	14	97	108	..	135	..	62	93	93	118	177
B.											
Killarney	14	111	105	..	..	..	..	89	92	103	171
Ferns	..	104	105	..	..	278	..	85	90	107	..
Woodenbridge	..	91	102	..	..	281	..	94	..	95	..
C.											
Bembridge	12	94	96	96	*196*	303	62	79	92	..	187
Whitchurch Canonicorum	1	110	87	110	..	..	69	65	79	..	..
Bere Regis	..	79	82	90	..	..	..	..	..	..	..
Blandford	17	93	90	107	110	..	52	92	78	77	94
Buckhorn Weston	33	104	93	97	105	299	38	87	83	90	174
Pennington	21	96	101	107	..	293	58	83	86	138	180
Strathfield Turgiss	32	98	93	106	123	285	71	83	98	127	173
Bexhill-on-Sea	12	109	90	103	121	306	60	80	93	125	148
Muntham	28	95	92	102	147	286	28	91	91	136	..
Dover	..	113	..	..	..	299	..	..	..	..	..
Farnborough	..	111	102	105	..	..	..	..	..	..	..
Swanley	..	..	98	..	..	..	..	100	91	..	..
Chislehurst	17	109	91	103	127	286	61	87	93	149	..
Coneyhurst	..	101	95	97	121	276	79	101	..	..	..
Churt Vicarage	31	101	96	108	..	283	55	87	97	125	179
Churt	13	92	97	100	124	298	..	..	98	124	126
Cranleigh	38	95	93	102	124	293	35	97	61	108	140
Winterfold	28	97	94	103	122	289	28	85	..	..	..
Oxshott	33	110	99	106	..	..	..	..	..	..	..
Ashtead	..	94	97	101	..	..	55	..	84	119	..
Addlestone	36	105	99	111	102	..	50	34	..	..	..
East Molesey	10	112	107	..	..	*257*	39	62	88	119	..
Marlborough	26	101	101	..	..	..	..	..	84	133	167
Whatley	..	97	97	115	138	277	80	92	90	92	165
Reading	*44*	..	..	..	..	..	..	83	83	..	..
D.											
Oxford	21	103	98	..	..	..	..	..	83	..	..
Cheltenham	15	105	105	*119*	144	285	70	84	91	..	181
Beckford	12	103	97	107	139	293	12	101	86	103	..
Watford	..	102	..	107	*153*	..	..	92	90	..	..
St. Albans (The Grange)	..	..	100	100	..	..	..	75	82	..	..
St. Albans (Add. Lodge)	22	116	112	106	..	..	39	42	84	119	..
St. Albans (Worley Road)	22	105	98	105	138	301	..	..	..	..	..

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TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1894—*Continued.*

Station.	Song.	Migration.					Insects.				
	Song Thrush First heard.	Swallow First seen.	Cuckoo First heard.	Nightingale First heard.	Flycatcher First seen.	Swallow Last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
D.											
Radlett	35	109	97	100	136	..	58	91	..	..	..
Berkhamsted	14	97	98	105	110	296	62	80	80	133	..
Harpenden	..	94	98	106	..	..	..	104	95	92	..
Ross	..	103	107	..	134	286	39	91	..	..	..
Breinton	..	107	98	..	141	284	62	95	85	93	..
Evesham	..	..	..	104	..	269	29	..	..	144	182
Henley-in-Arden	..	107	98	109	..	..	..	..	83	121	..
Northampton	..	..	98	99	..	..	75	..	90	..	..
Churchstoke	41	116	99	..	144	..	65	100	98	103	180
Burbage	12	113	99	..	141	284	35	79	88	*152*	..
Thurcaston	..	98	..	..	..	..	..	..	95	138	..
Uppingham	..	..	*81*	117	*111*	..	..	..	..	..	111
Tean	35	102	106	..	..	280	69	..	90	..	..
Beeston	..	102	106	..	..	277	..	90	87	..	..
Hodsock	36	101	105	119	141	281	21	99	82	111	..
Macclesfield	40	117	105	..	..	276	62	79	101	..	..
Belton	19	105	102	111	140	321	18	91	..	144	..
Harrogate	35	99	105	..	130	324	77	74	100	..	..
E.											
Hatfield	..	114	99	102	..	..	..	..	..	..	..
Hitchin	14	102	101	..	..	..	12	71	87	..	..
Ashwell	..	111	102	107	140	300	..	..	..	..	..
Bocking	..	..	93	..	..	..	..	..	..	..	..
Lexden	21	109	100	107	..	283	33	92	85	108	182
Sproughton	16	110	102	105	133	318	35	85	98	111	..
Tacolneston	..	101	99	..	..	..	..	..	..	118	..
F.											
Ellesmere	..	..	100	..	..	..	..	..	.	115	..
Penmaenmawr	..	112	99	..	..	285	75	82	..	..	..
Claughton	..	113	112	..	..	..	..	..	..	..	..
Giggleswick	36	108	109	..	131	282	..	..	..	..	..
Ambleside	43	105	105	..	..	..	..	..	*118*	118	..
Egremont	15	105	107	..	117	264	30	92	89	117	182
Cronkbourne	..	..	..	..	..	269	..	..	..	..	..
Orry's Dale	36	..	*138*	..	..	..	35	..	..	..	..
Sulby	48	109	119	..	..	283	74	88	108	..	150
G.											
Edgeworthstown	..	105	108	..	..	..	79	..	87	109	..
Westport	..	91	109	..	..	268	..	36	..	..	..
Loughbrickland	41	106	110	..	..	272	38	..	109	118	..
Saintfield	31	98	117	..	..	..	..	..	108	120	..
Antrim	36	105	107	..	143	272	87	143	118	..	..
Ballymena	..	108	116	..	*167*	..	..	109	108	117	182
Londonderry	19	104	119	..	..	..	109	120	108	109	178
Ballynagard	1	105	116	..	..	..	..	..	117	108	..
Ramelton	..	98	101	..	..	263	..	101	..	..	..
H.											
Dalshangan	40	118	109	..	..	..	72	..	98	..	..
Tynron	51	113	109	..	..	261	..	..	111	..	..
Thornhill	..	109	116	..	..	..	67	59	.	..	..
Jardington	35	103	107	..	140	..	..	87	101	..	194
Helensburgh	21	*120*	117	..	..	..	75	112	118	..	..
I.											
Doddington	..	..	98	..	..	..	..	..	..	..	..
Great Cotes	..	111	..	..	135	..	..	..	..	..	..

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TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1894—*Continued.*

Station.	Song.	Migration.					Insects.				
	Song Thrush First heard.	Swallow First seen.	Cuckoo First heard.	Nightingale First heard.	Flycatcher First seen.	Swallow Last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
I.											
Thirsk	..	109	104	..	..	287	32	37	87	150	..
East Layton	35	115	111	..	132	284	57	83	85	145	..
Durham	36	123	113	..	141	..	78	114	110	..	..
Low Fell	45	..	120	..	..	265	..	100	..	..	..
Cambois	..	117	120	..	..	279	83	106	83	..	..
Lilliesleaf	..	118	119	..	136	269	51	121	..	..	..
J.											
Aberdeen	15	122	121	..	130	270	90	142	144	172	..
K.											
Inverbroom	..	..	119	..	176	..	74	87	..	..	..
Mean Dates for the British Isles in 1894	26 Jan. 26	April 15	April 13	April 16	May 12	Oct. 12	Feb. 24	March 29	April 2	April 28	June 13
Mean Dates for 1891–3	Feb. 3	April 17	April 23	April 23	May 13	Oct. 14	Feb. 26	April 6	April 11	May 6	June 8

The dates in italics have not been taken into consideration when calculating the means for the British Isles.

The apple blossom suffered so greatly during the frosts of May that the crop of fruit was almost everywhere a failure. The yield of plums was also small, except in the south-western, southern, and eastern counties of England, where it was about average. The pear crop proved a remarkably heavy one in most parts of England, but this was far from being the case in Scotland or Ireland. Mr. G. Bunyard, of Maidstone, a well known authority on fruit culture, attributes the enormous crop of pears in England to the following causes, viz.: The small yield in 1893, the heavy rains of the previous autumn, and the well ripened wood. He accounts for the crop escaping destruction by the May frosts to the early flowering of the trees and the pendent character of the blossoms.

The autumn tints were generally poor, owing to the sunless character of October. Wild berries of all kinds were exceptionally abundant, especially holly berries.

The dates for the ivy are very variable, but in most districts later than the average.

In certain localities the swallow was very late in taking its departure, but, taking the country as a whole, this comes out only three days later than in 1893.

The Year.

Between the third week in March and the third week in May plants came as a rule into blossom in advance of their usual time, and towards the end of

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TABLE VI.—Estimated Yield of Farm Crops in 1894.

Description of Crop.	England.						Scotland.			Ireland.	British Isles.
	A. SW.	C. S.	D. Mid.	E. E.	F. NW.	I. NE.	H. W.	J. E.	K. N.	B. and G. S and N.	
Wheat	5% O. Av.	6% O. Av.	8% O. Av.	5% O. Av.	9% O. Av.	1% O. Av.	1% O. Av.	3% O. Av.	9% O. Av.	O. Av.	O. Av.
Barley	6% O. Av.	5% O. Av.	11% O. Av.	6% O. Av.	10% O. Av.	2% O. Av.	3% O. Av.	Av.	15% O. Av.	O. Av.	O. Av.
Oats	12% O. Av.	16% O. Av.	13% O. Av.	5% O. Av.	11% O. Av.	4% O. Av.	6% O. Av.	5% O. Av.	16% O. Av.	O. Av.	Much O. Av.
Corn Harvest began, average Date	225 (Aug. 13)	218 (Aug. 6)	224 (Aug. 12)	218 (Aug. 6)	228 (Aug. 16)	233 (Aug. 21)	249 (Sept. 6)	242 (Aug. 30)	246 (Sept. 3)	239 (Aug. 27)	232 (Aug. 20)
Beans	Av.	Av.	U. Av.	O. Av.	Av.	O. Av.	Av.	O. Av.	..	O. Av.	O. Av.
Peas	Av.	O. Av.	Av.	U. Av.	Av.	O. Av.	..	Av.	..	O. Av.	Av.
Potatoes	U. Av.	U. Av.	Av.	Av.	Av.	U. Av.	U. Av.	Av.	O. Av.	Av.	U. Av.
Turnips	Av.	O. Av.	O. Av.	O. Av.	Av.	U. Av.	O. Av.	Av.	Av.	Av.	O. Av.
Mangolds	O. Av.	O. Av.	Av.	O. Av.	Av.	Av.	Av.	Av.	..	Av.	O. Av.
Hay (Permanent Pastures)	26% O. Av.	37% O. Av.	23% O. Av.	14% O. Av.	19% O. Av.	8% O. Av.	8% O. Av.	10% O. Av.	9% O. Av.	Much O. Av.	Much O. Av.
Hay (Clover, &c.)	22% O. Av.	22% O. Av.	11% O. Av.	2% O. Av.	15% O. Av.	14% O. Av.	9% O. Av.	18% O. Av.	15% O. Av.	Much O. Av.	Much O. Av.

The variations from the average (1885-94) relating to Wheat, Barley, Oats and Hay have been obtained from the *Agricultural Produce Statistics* issued by the Board of Agriculture, but those for the other crops from Returns which appeared in the *Agricultural Gazette*.

TABLE VII.—Estimated Yield of Fruit Crops in 1894.

Description of Crop.	England.						Scotland.	Ireland.	British Isles.
	A. SW.	C. S.	D. Mid.	E. E.	F. NW.	I. NE.	H. J. and K. W. E. and N.	B. and G. S. & N.	
Apples	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Much U. Av.
Pears	O. Av.	O. Av.	O. Av.	O. Av.	Av.	U. Av.	U. Av.	U. Av.	O. Av.
Plums	Av.	Av.	U. Av.	Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.
Raspberries	Av.	Av.	U. Av.	Av.	Av.	U. Av.	Av.	Av.	Av.
Currants	Av.	Av.	U. Av.	Av.	Av.	U. Av.	Av.	Av.	Av.
Gooseberries	Av.	Av.	U. Av.	Av.	Av.	U. Av.	Av.	Av.	Av.
Strawberries	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Much U. Av.

Symbols:—O. = Over. U. = Under. Av. = Average. This Table has been compiled from Returns which appeared in the *Gardeners' Chronicle*.

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TABLE VIII.

APPROXIMATE VARIATIONS FROM THE AVERAGE IN MEAN TEMPERATURE, RAINFALL, AND SUNSHINE, 1893–94.

Winter 1893–94.

Temperature.

Months.	Eng. SW.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. NW.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
December	+2·3	+2·5	+1·8	+3·0	+2·0	+3·3	+2·5	+4·0	+3·3	+4·0	+3·5
January	−0·8	−1·6	−0·4	−2·0	−0·4	0·0	−1·0	0·0	−0·6	−0·4	−0·4
February	+1·0	+1·5	+1·0	+0·8	+0·8	+1·3	+1·3	+1·3	+0·3	+0·3	−0·3
Winter ...	+0·8	+0·8	+0·8	+0·6	+0·8	+1·5	+0·9	+1·8	+1·0	+1·3	+0·9

Rain.

	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
December	+0·5	+1·5	+0·2	+0·3	−0·5	+0·5	+0·7	+1·3	−0·8	−0·1	+2·7
January	−0·1	+1·0	+0·2	−0·6	−0·3	+0·1	+1·9	+0·6	−0·4	+0·7	+2·4
February	+0·3	−0·1	−0·1	+0·5	−0·5	+1·9	+1·9	+4·1	+1·2	+3·1	+4·0
Winter	+0·7	+2·4	+0·3	+0·2	−1·3	+2·5	+4·5	+6·0	0·0	+3·7	+9·1

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
December	+ 7	+ 2	+12	+ 5	+14	− 5	+ 5	− 7	− 1	−10	−17
January	+18	0	+23	+16	+17	+18	+ 4	+ 5	+11	− 9	− 2
February	+11	+ 5	+27	+24	+36	− 1	+ 4	− 3	+20	+28	− 6
Winter	+36	+ 7	+62	+45	+67	+12	+13	− 5	+30	+ 9	−25

Spring 1894.

Temperature.

	°	°	°	°	°	°	°	°	°	°	°
March	+2·0	+1·8	+2·8	+2·0	+2·3	+3·3	+2·3	+3·0	+2·3	+2·5	+2·8
April	+3·3	+2·5	+4·3	+3·5	+3·0	+3·5	+3·0	+3·5	+2·5	+2·5	+3·8
May	−1·6	−1·6	−1·6	−2·8	−2·0	−2·6	−2·8	−2·4	−2·2	−2·4	−2·2
Spring	+1·2	+0·9	+1·8	+0·9	+1·1	+1·4	+0·8	+1·4	+0·9	+0·9	+1·5

Rain.

	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
March	−0·3	−0·4	−0·7	−0·5	−0·6	0·0	−0·2	−0·2	−0·9	−0·6	+1·0
April	−0·1	+1·8	0·0	0·0	+0·2	−0·2	+0·6	−0·6	−0·7	−0·7	−1·9
May	+0·4	+0·2	+0·1	−0·4	+0·5	+0·8	+0·2	+0·3	+1·0	+1·0	+0·3
Spring	0·0	+1·6	−0·6	−0·9	+0·1	+0·6	+0·6	−0·5	−0·6	−0·3	−0·6

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
March	+57	+ 41	+ 57	+ 59	+ 58	+ 68	+ 64	+ 64	+ 78	+ 72	+ 39
April	+18	− 24	+ 9	+ 19	− 4	+ 14	− 21	− 16	+ 16	− 13	+ 19
May	− 9	− 14	− 21	− 23	− 33	− 18	− 11	− 6	− 8	+ 14	+ 45
Spring	+66	+ 3	+ 45	+ 55	+ 21	+ 64	+ 32	+ 42	+ 86	+ 73	+103

\+ indicates above the average, — below it.

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TABLE VIII.

VARIATIONS FROM THE AVERAGE—*Continued.*

Summer 1894.

Temperature.

Months.	Eng. SW.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. NW.	Ire. N.	Scot. W.	Eng. NE.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
June	−0·8	0·0	−0·5	−0·5	−0·8	−1·0	−0·8	−0·8	−1·0	−1·0	+0·3
July	−0·8	−0·5	−0·3	−0·3	−0·3	+0·5	+0·3	+0·5	+1·0	+0·8	+2·3
August	−1·0	−1·2	−0·8	−1·2	−1·4	−1·2	−0·8	−0·8	−1·2	−0·6	+0·4
Summer ..	−0·9	−0·6	−0·5	−0·7	−0·8	−0·6	−0·4	−0·4	−0·4	−0·3	+1·0

Rain.

	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
June	−0·1	−0·2	0·0	−0·3	+0·4	0·0	0·0	+0·1	+1·1	−0·2	−0·6
July	+1·2	+1·2	+1·8	0·0	+0·6	−0·1	+0·7	−0·6	0·0	+0·9	+1·5
August	+0·2	+0·1	+0·4	−0·3	−0·3	+0·6	−1·0	−0·4	−0·3	+1·1	+1·0
Summer ..	+1·3	+1·1	+2·2	−0·6	+0·7	+0·5	−0·3	−0·9	+0·8	+1·8	+1·9

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
June	− 37	−21	−16	−17	−37	− 9	−16	− 18	−17	−22	+22
July	− 27	−17	−11	0	−14	+ 5	+ 7	+ 7	+30	−17	+28
August	− 53	−75	−50	−50	−30	−53	−27	−15	−26	− 8	+ 7
Summer ..	−117	−113	−77	−67	−81	−57	−36	−26	−13	−47	+57

Autumn 1894.

Temperature.

	°	°	°	°	°	°	°	°	°	°	°
September ..	−1·5	−2·0	−2·0	−2·3	−2·5	−1·8	−1·3	−1·8	−1·8	−1·3	−0·8
October	+1·2	+1·0	+1·8	+1·2	+1·4	+0·6	+1·0	−0·4	0·0	−0·6	0·0
November	+1·8	+0·8	+2·8	+2·5	+2·3	+3·0	+1·5	+3·8	+2·5	+2·8	+3·8
Autumn ..	+0·5	−0.1	+0·9	+0·5	+0·4	+0·6	+0·4	+0·5	+0·2	+0·3	+1·0

Rain.

	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
September ..	−1·4	−2·3	−0·3	−1·1	−0·4	−2·9	−3·0	−4·0	−1·3	−2·2	−3·9
October	+1·0	+1·6	+1·3	+0·3	−0·2	+0·5	+0·2	−0·6	+1·3	−0·1	−2·8
November	+2·3	+1·0	+1·1	+0·7	+0·5	−0·7	−0·6	+0·3	−1·4	−1·6	+0·1
Autumn ..	+1·9	+0·3	+2·1	−0·1	−0·1	−3·1	−3·4	−4·3	−1·4	−3·9	−6·6

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
September....	+10	+27	−30	−14	−23	+23	+37	+34	+ 5	+ 7	−22
October	−10	− 5	−41	−34	−33	+ 3	+12	−14	−30	+ 1	−15
November	+12	+14	+31	+16	+18	+ 4	+13	+ 7	+10	+23	0
Autumn....	+12	+36	−40	−32	−38	+30	+62	+27	−15	+31	−37

The above Table has been compiled from the variations from the mean given in the *Weekly Weather Reports* issued by the Meteorological Office.

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April the dates of first flowering differed but little from those recorded at the same period in the remarkably forward spring of 1893. The cuckoo made its appearance exceptionally early, even earlier than in the previous year—in many places from a week to a fortnight earlier. The year 1894 was a very productive one. Both the hay and corn crops proved unusually heavy, but

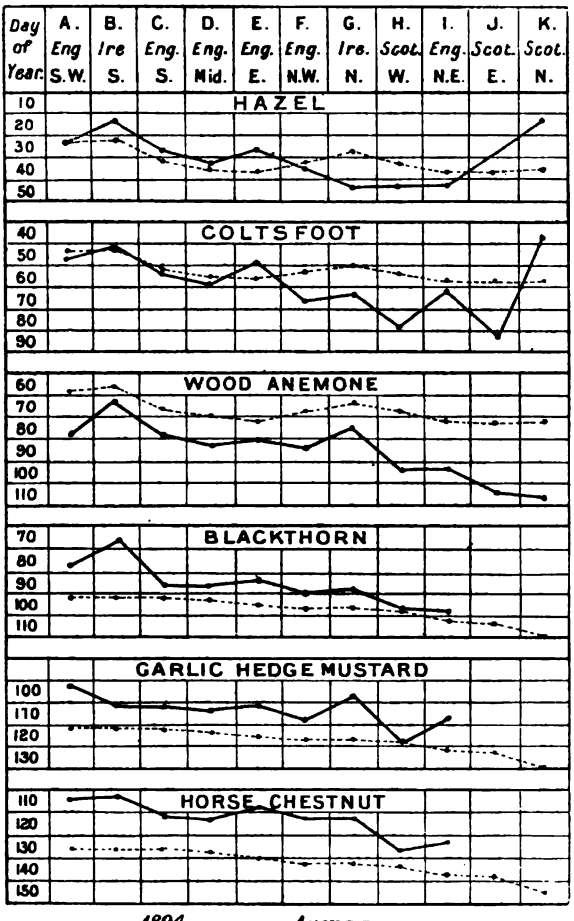

FIG. 2.—Mean Dates (Day of Year) of Flowering of the Plants in 1894, and also the Average Dates.

much of the latter was harvested under very trying conditions as regards weather. The frosts of May 21st and 22nd entirely destroyed the previous prospect of a glorious fruit season. Indeed, the only really good crop was that of pears, which throughout nearly the whole of England were very abundant.

Observers' Notes.

DECEMBER 1893.—*Mawnan Smith* (A.). 2nd. Dahlias killed. 29th. First hazel catkins out in sheltered valley. Falmouth (A.). During this month 48

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different sorts of wild flowers were gathered within a radius of 5 miles. *Tiverton* (A.). 22nd. Violets and a hepatica in flower in garden. *Bassaleg* (A.). I never remember fruit trees with such well ripened wood or having a better promise of bearing in the succeeding year. *Blandford* (C.). 13th. Black guillemot were picked up near here in an exhausted state after the blizzard of the previous day. *Pennington* (C.). 30th. Winter aconite in flower. *Burbage*

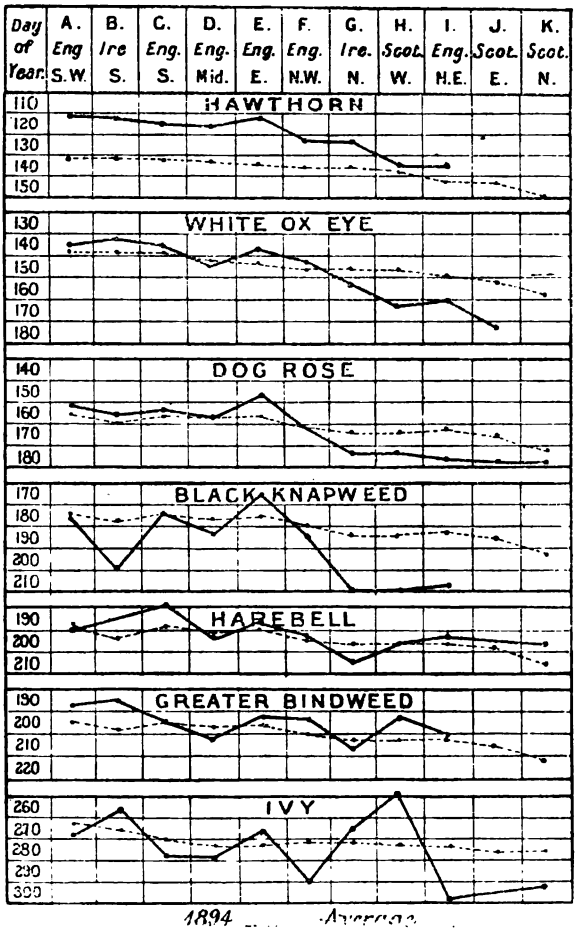

FIG. 3.—Mean Dates (Days of Year) of Flowering of the Plants in 1894, also the Average Dates.

(D.). Holly berries comparatively scarce. *Loughbrickland* (G.). All the hollies in this district shed their leaves at the end of November. This I attribute to the previous dry summer. *Saintfield* (G.). 15th. Gorse in flower as if it were March.

JANUARY 1894.—*Mawnan Smith* (A.). 26th. Wild primrose in blossom. *Falmouth* (A.). 5th. Camellias in bloom in the open air. *Sidcot* (A.). During the first week flowers came out in quick succession. *Aberystwith* (A.). 29th. Frog spawn first seen. *Bembridge* (C.). 2nd-4th. Piercing North-east winds which penetrated houses and stores which had never been reached by frost before, and destroyed seed potatoes and dahlia roots. *Addlestone* (C.).

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28th. Winter aconite in flower. *Berkhamsted* (D.). 17th. Winter aconite in flower, earliest since 1890. *Evesham* (D.). 24th. Hazel catkins out. *Burbage* (D.). 18th. Winter aconite in flower. *Tean* (D.). Primroses found in flower, a very uncommon thing here in January. Hazel catkins exceptionally fine. *Hodsock* (D.). 13th. Winter aconite in flower. *Harrogate* (D.). 6th. The exposed thermometer fell to —8°·7. Berberis Darwinii, Aucuba Japonica, and Ulex Europæus were killed outright. *Hitchin* (E.). 2nd. Hazel catkins out. *Tacolneston* (E.). 19th. Hazel catkins very abundant. *Antrim* (G.). 6th. Evergreens suffered greatly from severe frost, Portuguese laurels became entirely brown. *Dalshangan* (H.). 1st. Winter aconite in flower. *Lilliesleaf* (I.). 5th. Winter aconite in flower. *Aberdeen* (J.). 6th. The severest frost since 881. Shrubs suffered severely, but not low growing vegetation, which was overed with 4 ins. of snow.

FEBRUARY.—*Barnstaple* (A.). 28th. Vegetation singularly forward, the average number of species of wild flowers recorded by me for the previous 20 years is 16 for the end of February; in 1893, 27 were recorded; and in 1894, 35. *Bembridge* (C.). 21st. Picked a dish of mushrooms from a bank out of doors. *Whitchurch Canonicorum* (C.). 14th. In the village children's wild flower class 30 different species of wild flowers were registered. *Pennington* (C.). Winter migrants very scarce. *Burbage* (D.). 22nd. Rooks began building. *Harrogate* (D.). 25th. Frog spawn first seen. *Tynron* (H.). 23rd. Curlew first seen. *Durham* (I.). Woodcock and snipe very scarce, especially the former.

MARCH.—*Aberystwith* (A.). 26th. About 26 wild flowers out, only half that number in 1893. *Bembridge* (C.). 31st. Cut asparagus out of doors. Vegetation very forward. *Pennington* (C.). Queen wasps plentiful. *Whitchurch* (C.). 21st. Queen wasps found together in a crevice of garden wall coping. *Tean* (D.). 10th. Primroses as abundant as they are usually at the beginning of April. *Hitchin* (E.). Queen wasps last winter hibernated together in great numbers, as many as filled an old teapot were found under a tarpaulin on an outhouse roof.

APRIL.—*Tiverton* (A.). 20th. Hawthorn out on five different bushes (specimens received). *Westward Ho* (A.). Queen wasps numerous. *St. Arvans* (A.). 11th. Hailstones as large as nuts, which cut off fruit and slit rose and other leaves. *Killarney* (B.). 26th. Corncrake first heard. *Woodenbridge* (B.). 17th. Corncrake first heard. *Bembridge* (C.). 18th. Gloire de Dijon rose in flower on wall of house. *Pennington* (C.). 26th. Swift first seen. *Strathfield Turgiss* (C.). 22nd. Hawthorn extraordinarily full of blossom, and trees perfectly white. *Churt* (C.). Took between 70 and 80 wasps early in the month. Ladybirds abundant. *Berkhamsted* (D.). 2nd. Wild cherry in flower. *Burbage* (D.). 30th. Landrail first heard. *Beeston* (D.). 28th. Corncrake first heard. *Lexden* (E.). 29th. Swift first seen. *Settle* (F.). The collector of plovers' eggs for market said he had never known them so early. *Sulby* (F.). 27th. Corncrake first heard. *Edgeworthstown* (G.). 18th. Corncrake first heard. *Loughbrickland* (G.). 23rd. Corncrake first heard. *Thirsk* (I.). 18th. Apricots as large as cherries. *East Layton* (I.). 22nd. Never recollect seeing blackthorn so laden with blossom. *Inverbroom* (K.). 16th. Pear blossom over and fruit set.

MAY.—*Mawnan Smith* (A.). A great many queen wasps this spring. Hawthorn remarkably full of blossom. 17th. Swift first seen. *Barnstaple* (A.). The past 12 years' average for the number of wild flowers observed by me in blossom at the end of May is 170. Number observed in 1893—240, in 1894—227. *Long Ashton* (A.). More cuckoos and swallows than I remember here for 18 years. *Penarth* (A.). 21st. Frost blackened many potatoes about Penarth and Cardiff. Spring butterflies scarce. *Bassaleg* (A.). The frost of 21st and continuous East wind and cold nights have injured strawberries and apples more than I ever remember before. *St. Arvans* (A.). 31st. Hawthorn blossom especially abundant, every bush and hedge being as white as snow. *Killarney* (B.). 20th-22nd. The severest frost since May 1864. Even briar, ivy and ash shoots much injured. *Woodenbridge* (B.). Frosts on 21st, 22nd and 23rd, which blackened potatoes, beans, &c., and caused gooseberries to fall from the trees. *Bembridge* (C.). 20th and 21st. No injuries by frost here although exposed to the north-east. *Buckhorn Weston* (C.). 20th. Sharp frost,

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which cut back potatoes, damaged fruit blossom, and caused gooseberries to drop off. *Twyford* (C.). Although on high ground, the frost of 20th destroyed at least 10,000 young rose blooms and 200 newly planted dahlias. *Strathfield Turgiss* (C.). A very forward spring up to the 21st, when a very keen frost literally cut everything to pieces—laurels, ash trees and horsechestnuts suffered severely. Cuckoos very abundant, nightingales comparatively scarce. *Farnborough* (C.). The frost of the 19th cut off buds of the dog rose ready to open and almost entirely destroyed strawberry crop. *Chislehurst* (C.). All flowering shrubs exceedingly full of blossom, especially hawthorn. *Coneyhurst* (C.). Hawthorn more thickly flowered than for some years. *Churt Vicarage* (C.). A very great number of queen wasps till after frost in third week. The frosts of 20th and 21st, and the succeeding cold weather, have done more harm than I ever remember. The young foliage and shoots of trees and hedges are blackened as if by fire. *Churt* (C.). Chestnut growths of underwood especially presented a black and scorched appearance after frosts of 20th and 21st. Butterflies scarce. *Cranleigh* (C). The frost of 21st, followed by a bright sun in the early morning, did much damage, especially among the potatoes. *Winterfold* (C). The frosts of 20th and 21st, with hail and snow on both days, injured underwood and fruit blossoms, and cut bracken to the ground. *Oxshott* (C.). The frost did not do much harm here, but was severe in the low ground in the neighbourhood. *Marlborough* (C.). Frosts of the 20th and 21st cut back vegetation severely. *Oxford* (D.). The blossom on chestnut, lilac, laburnum and lime particularly fine. *Beckford* (D.). Potatoes and kidney beans practically killed by frost of 21st, while fruit trees and strawberries suffered severely. The damage sustained was all on the low lying lands, on the high ground over 100 ft. above the brook there was no frost. *St. Albans* (*The Grange*) (D.). 22nd. Sharp ground frost, which did much damage to fruit blossom and vegetation generally. *Radlett* (D.). 13th. First swarm of bees. *Harpenden* (D.). The frosts at end of third week almost entirely destroyed apple blossom. Gooseberry bushes almost bared of their fruit. Potatoes so injured that they never recovered, and yielded minute tubers only. *Ross* (D.). 14th. Corncrake first heard. *Breinton* (D.). Frosts of 19th, 20th, and 21st cut oaks, ashes, nettles, &c. *Burbage* (D.). Hawthorn blossom very plentiful. *Thurcaston* (D.). Enormous show of bloom of all kinds. The frosts have not done much harm here. *Tean* (D.). 24th. Young oak and ash leaves blackened, and potatoes killed by the frost. *Hodsock* (D.). 21st. Potatoes blackened, strawberry blossom destroyed, and young shoots of ivy, oaks, and ash touched. *Macclesfield* (D.). 1st. Sycamores and hawthorn in full leaf and bloom. Fruit blossom very abundant. Blossom on fruit trees and strawberries destroyed by frost towards the end of the month. Laburnums nearly stripped of bloom, ash bloom and leaves all killed, young shoots of sycamore, alder, poplar, and hawthorn also killed. *Belton* (D.). 20th and 21st. Everything being wet, great damage was done by the frost. Some oaks completely blackened, others partially so, according to position. Ash trees blackened and appear as if dead. *Hitchin* (E.). 20th and 21st. Potatoes and beans cut off by frost. Oak, ash, elms, beech, maple, elder, plums, gooseberries, currants, strawberries, thistles, plantains, and ivy frostbitten. *Ashwell* (E.). 10th. Swift first seen. 21st and 22nd. Sharp frosts: geraniums, dahlias, &c. cut down. *Sproughton* (E.). 21st. The disastrous frost experienced in many parts of the country was here modified by a slight snow shower between 4 and 5 a.m., which probably was of great service to vegetation. *Tacolneston* (E.). 21st. Potatoes killed to the ground in exposed places by frost. *Ellesmere* (F.). 20th. Young shoots of oak, ash, ivy, hawthorn, &c. killed by frost. *Pennaenmawr* (F.). Fruit blossom not quite as abundant as in 1893, but hawthorn very full of bloom. 25th. Much damage done to young potatoes by frost. *Claughton* (F.). 20th, 21st, and 22nd. Potatoes and dahlias cut by frost. *Giggleswick* (F.). 21st and 22nd. Great damage to trees, potatoes, &c. by frost. An ash tree just showing leaves on May 1st was scarcely in full leaf by June 1st. *Ambleside* (F.). 20th-22nd. Young growths on beech, oak, and spruce, which were very forward, destroyed by frost. *Egremont* (F.). 20th and 21st. Great damage done to potatoes and vegetation in general by frost. *Loughbrickland* (G.). 20th and 21st. Potatoes cut to the ground, and the new growths of oak, ash, sycamore, silver fir, box, and bay laurel killed by frost. *Antrim* (G.). 20th and 21st. Potatoes cut to the ground by frost and young shoots of the ivy,

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ash, beech, &c. appeared afterwards as if scorched by fire. *Ballymena* (G.). 10th. Corncrake first heard. 12th. Swift first seen. *Hazelbank* (G.). A special feature of the season was the profusion of blossom on the hawthorn. *Tynron* (H). 20th and 21st. Potatoes withered to the ground by frost. Ash, oak, and young larch trees also suffered. Gooseberries dropped a considerable portion of their fruit. *Jardington* (H.). 21st-24th. Potatoes cut down by frost, gooseberry fruit dropped off the bushes, and all young leaves on beeches and other trees were frozen. *Thirsk* (I.). 20th. Only potatoes in sheltered gardens escaped injury from frost. Plums, currants and gooseberries also suffered severely. *East Layton* (I.). 20th. Ground covered with snow and 4° of frost. *Durham* (I.). 12th. Swift first seen. 20th-25th. Frost cut off about everything that could be injured. Great damage to potatoes and fruit blossom. *Low Fell* (I.). 8th. Corncrake first heard. 10th. Swift first seen. *Cambois* (I.). 19th-23rd. Potato tops frozen off. The young fruit and blossoms perished. Foliage of beech, sycamore, chestnut, and oak appeared afterwards as if burnt. *Lilliesleaf* (I.). 20th. Showers of hail. Potatoes blackened by frost. *Aberdeen* (J.). 20th. Frost injured fruit blossom, also turnips in the fields where they were through the ground. *Inverbroom* (K.). 20th. Wasps very plentiful till after this frost, when there were none left.

JUNE—*Tiverton* (A.). 3rd. Wild strawberry ripe. *Bassaleg* (A.). 9th. Have never before seen apple and pear trees so badly affected with blight. *Strathfield Turgiss* (C.). Butterflies very scarce. 4th. Dog rose unusually full of blossom. *Chislehurst* (C.). All butterflies very scarce this year. *Watford* (D.). Fruit trees much blighted. Dog rose blossom very abundant. *Berkhamsted* (D.). 30th. Roses greatly infested with greenfly this year. *Tean* (D.). 17th. Ash trees still thin, mostly only half out. *Hodsock* (D.). A great deal of greenfly on roses. *Inverbroom* (K.). Swallows nested here and brought out young for the first time in my experience. Flycatchers very rarely come here, but several pairs nested this year, and the same may be said of whitethroats. 28th. Oats in ear. 30th. Raspberries ripe.

JULY.—*Killarney* (B.). Currant trees almost fruitless this year. *Bembridge* (C.). 20th. Potato disease first observed, and very bad throughout the Island. *Chislehurst* (C.). No swarms of bees this summer, and very little honey. *Beeston* (D). 6th. Privet and laurel in great bloom. 31st. Mushrooms in great abundance. *Macclesfield* (D.). 24th. An Easterly gale did much damage to foliage of trees, and some maize plants in my garden were killed.

AUGUST.—*Marazion* (A.). Butterflies have been very scarce, especially white varieties. 25th. Swift last seen. *Mawnan Smith* (A.). Weeds and slugs unusually numerous this summer. *Long Ashton* (A). Very few butterflies this year. *Killarney* (B.). Almost a total absence of wasps and mushrooms. *Woodenbridge* (B.). Swifts left. *Bembridge* (C.). 14th. Clouded yellow butterfly seen, rather scarce this year. *Buckhorn Weston* (C.). The bee orchis, previously plentiful, has entirely disappeared from its usual habitat, also frog orchis, while the butterfly and palmate orchis have been very scarce. *Pennington* (C). 25th. Swift last seen. *Strathfield Turgiss* (C.). Swifts congregating in hundreds. 6th Swifts all gone. *Churt* (C.). Wasps scarce. The crop of hazel nuts the finest I have ever seen. *East Molesey* (C.). Wasps very scarce. *Cheltenham* (D.). Wasps comparatively few and small in size. Remarkably few butterflies and moths. Earwigs very abundant. *Watford* (D.). Butterflies very scarce. *Evesham* (D.). Remarkable scarcity of butterflies this year. *Jardington* (H.). Great scarcity of wasps this summer. *Lilliesleaf* (I.). 27th. A plague of flying ants: steps and windowsills were literally covered with them, also one's clothes. The following day they seemed to have disappeared.

SEPTEMBER.—*Sidcot* (A.). Blackberries abundant, but without flavour. *Long Ashton* (A.). A great quantity of holly, hawthorn, and rose berries. *St. David's* (A.). Haws very abundant. *Woodenbridge* (B.). Beechmast plentiful. *Pennington* (B). Haws, blackberries, and holly berries especially abundant. Very few wasps or butterflies, but slugs numerous this year. *Chislehurst* (C.). 20th. Finished picking hops. *Cheltenham* (D.). Wild flowers scarce all through the autumn. *Beeston* (D.). A scarcity of wasps. *Hodsock* (D.). Harvest finished. *Hitchin* (E.). Haws and holly berries very plentiful. *Ashwell* (E.). Swift last seen

OCTOBER.—*Sidcot* (A.). Autumn tints not so good as usual, most of the leaves

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turning dull yellow with no red tints. *St. Arvans* (A.). Yew berries very abundant. *St. David's* (A.). Blackberries scarce. *Pennington* (B.). Autumn tints less vivid than usual. *Churt Vicarage* (C.). 16th. Dahlias killed by frost. *Churt* (C.). Acorns scarce. *Addlestone* (C.). 18th. Dahlias killed by frost. *Oxford* (D.). 5th. Lime trees bare. *Watford* (D.). 27th. Trees without rich autumn tints. *Cronkbourne* (F). 14th. Wasps still plentiful. 22nd. Dahlias cut down by frost. *Sulby* (F.). 18th. Woodcock first seen. *Edgeworthstown* (G.). Autumn foliage extraordinarily brilliant. *Ballymena* (G.). A second bloom of many flowers, also a second crop of raspberries and plums, which ripened. *Durham* (I.). 22nd. Dahlias killed by frost.

NOVEMBER.—*Mairnan Smith* (A.). Hawthorn and holly berries abundant. 6th. Gathered ripe wild strawberries. *Killarney* (B.). 14th. The brown leaves of a beech hedge falling, and a fresh growth of young green foliage expanding as in spring. *Woodenbridge* (B). Strawberries in bloom to end of month. 7th. Trees all bare. *Swanley* (C.). 8th. Ripe strawberries still on canes. *Churt* (C.). Holly berries and sweetbriar hips very abundant. *Addlestone* (C.). Holly berries a heavy crop. *Watford* (D.). Holly berries magnificent. *Berkhamsted* (D.). Holly berries exceptionally abundant. *Burbage* (D.). Holly berries exceptionally plentiful. *Durham* (I.). 2nd. Fieldfares first seen. 30th. Wild duck appearing.

Erratum in Phenological Report for 1893.

Hodsock.—A dish of strawberries was gathered on June 8th, *not* May 8th.

DISCUSSION.

Mr. F. C. BAYARD inquired what number of observers Mr. Mawley considered to be sufficient for the calculation of the averages of the 13 plants given in the table at the bottom of the diagrams of the dates of flowering for 1893 and 1894.

Dr. A. BUCHAN considered that the work done by Mr. Mawley in the preparation of this report was of great value. He had noticed one exceedingly remarkable feature in connection with the ripening of the corn crops during the past year in Scotland. He left Edinburgh on an inspection tour on August 12th, the crops in the neighbourhood then being as "green as leeks," but eight days afterwards, upon arriving in the South Shetlands, he was astonished to see the crops ripe and cut, and he was told that such a beautiful summer, more especially the months of July and August, had never before been experienced in the Shetlands within the memory of the oldest inhabitant. With regard to the serious frost in May, there appeared to have been considerable irregularity in the distribution of the areas of damage, and a gardener had informed him that in one fruit garden the apple blossoms were so completely destroyed by the frost that there were only two apples in the whole garden, while in a garden not far distant the frost appeared to have had no effect, there being a good yield of apples. Possibly the damage caused by the frost was dependent upon the condition of the blossom, as if the fruit was 'set' it would probably be better able to resist the frost than if the blossom was in an earlier stage. Referring to the migration of birds, he said that he considered their movements were regulated by the conditions of weather in the places from which they migrated.

Mr. G. J. SYMONS said that he greatly appreciated the able manner in which Mr. Mawley presented his statistics, and he thought that the table of averages of the thirteen plants for the years 1891 to 1894 proved the excellence of the observations, the agreement between the figures being so good. Concerning the disastrous frost in May, he said that he had occasion to travel through South Gloucestershire about a week before the date of the frost, and the apple orchards looked as though they were snow clad, the blossom being so profuse. He went through the same district a fortnight later, when he found that all the blossom had gone, as the frost had completely ruined what had promised so well.

ADMIRAL J. P. MACLEAR said that the growers in the neighbourhood of Guildford attributed the damage resulting from the frost in May to the action of strong sunshine upon the frost-nipped crops before their vitality had been sufficiently restored. One field of potatoes was shown him in which those plants which had lain in shadow previous to the sun shining upon them, had not suffered,

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while those which experienced the full power of the sunlight without any previous interval of shadow had been killed. One grower stated that if the plants could have been watered probably little damage would have been done.

Dr. A. BUCHAN inquired whether Mr. Mawley had been able to ascertain if the damage by frost was in any way dependent on the nature of the soil, as it appeared probable that plants on cold soils, such as clay, would be more likely to suffer than those grown on warmer soils.

Mr. E. MAWLEY, in reply, said that for the purpose of preparing averages he would much like to have from 15 to 20 observers in each district, but the actual number of observers was in many districts considerably fewer than that number. The results clearly showed that the best represented districts gave the best results, while those which are imperfectly represented caused the curve to become irregular. As regards the injury to fruit trees from cold or wet, the most critical period in their blossoming was when the flowers were fully expanded, but not yet fertilised. Therefore the nature of the soil, whether warm or cold, might in some cases account for certain fruit trees being affected, while others escaped injury, from the May frosts although growing in the same locality. It was generally understood that the migration of birds to the British Isles was only to a certain extent controlled by the weather here, being principally regulated by their supply of food and the weather prevailing in the countries from which they come. The injurious effect of sunshine upon frost-bitten plants was well known to horticulturists, and he had himself once saved a number of crysanthemums by placing them in the shade before the sun had acquired sufficient power to hurt them. An enthusiastic rosarian with whom he was acquainted, on one occasion, fearing a spring frost would injure his roses, turned the garden hose upon them early in the morning, and so saved his plants, while the foliage of other roses in the same district were greatly damaged.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

January 16th, 1895.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

DUNCAN J. CADDY, M.D., F.R.G.S., 4 Earl's Court Gardens, S.W.;
ENOCH GEORGE MAWBEY, Assoc.M.Inst.C.E., The Firs, Westleigh, Leicester;
EDWARD PRITCHARD, M.Inst.C.E., 37 Waterloo Street, Birmingham;
HENRY THOMAS SQUIRRELL, 5 Station Road, Bexhill-on-Sea; and
WALTER THOMAS, Assoc.M.Inst.C.E., Dover,
were balloted for and duly elected Fellows of the Society.

The following communication was read:—

"THE GALE OF DECEMBER 21ST-22ND, 1894, OVER THE BRITISH ISLES." By CHARLES HARDING, F.R.Met.Soc. (p. 92.)

January 16th, 1895.

Annual General Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

MR. F. J. BRODIE and MR. M. JACKSON were appointed scrutineers of the ballot for Officers and Council.

MR. F. C. BAYARD read the Report of the Council and the Balance Sheet for 1894 (p. 62).

It was proposed by the PRESIDENT, seconded by MR. F. C. BAYARD, and resolved:—"That the Report of the Council be received and adopted, and printed in the *Quarterly Journal*."

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It was proposed by PROF. J. K. LAUGHTON, seconded by MR. W. M. BEAUFORT, and resolved :—"That the thanks of the Society be given to the Officers and other Members of the Council for their services during the past year."

It was proposed by MR. A. BREWIN, seconded by MR. H. S. EATON, and resolved :—"That the thanks of the Society be given to the Standing Committees and to the Auditors, and that the Committees be requested to continue their duties till the next Council Meeting."

It was proposed by DR. C. T. WILLIAMS, seconded by ADMIRAL J. P. MACLEAR, and resolved :—"That the best thanks of the Royal Meteorological Society be communicated to the President and Council of the Institution of Civil Engineers for having granted the Society free permission to hold its Meetings in the rooms of the Institution."

The PRESIDENT then delivered an Address on "Weather Fallacies" (p. 49).

It was proposed by MR. R. H. SCOTT, seconded by DR. H. R. MILL, and resolved :—"That the thanks of the Society be given to MR. RICHARD INWARDS for his services as President during the past year, and for his Address, and that he be requested to allow it to be printed in the *Quarterly Journal*."

The scrutineers declared the following gentlemen to be the Officers and Council for the ensuing year :—

President.

RICHARD INWARDS, F.R.A.S.

Vice-Presidents.

ROBERT BARNES, M.D., F.R.C.P.
ROBERT WILLIAM PEREGRINE BIRCH, M.Inst.C.E., F.G.S.
CHARLES THEODORE WILLIAMS, M.A., M.D., F.R.C.P.
CAPTAIN DAVID WILSON-BARKER, F.R.G.S.

Treasurer.

HENRY PERIGAL, F.R.A.S., F.R.M.S.

Secretaries.

FRANCIS CAMPBELL BAYARD, LL.M.
GEORGE JAMES SYMONS, F.R.S.

Foreign Secretary.

ROBERT HENRY SCOTT, M.A., F.R.S.

Council.

ARTHUR BREWIN.
GEORGE CHATTERTON, M.A., M.Inst.C.E.
RICHARD HENRY CURTIS.
WILLIAM HENRY DINES, B.A.
WILLIAM ELLIS, F.R.S.
CHARLES HARDING.
BALDWIN LATHAM, M.Inst.C.E., F.G.S.
ADMIRAL JOHN PEARSE MACLEAR, R.N., F.R.G.S.
EDWARD MAWLEY, F.R.H.S.
HUGH ROBERT MILL, D.Sc., F.R.S.E., F.R.G.S.
HENRY SOUTHALL, F.R.H.S.
HERBERT SOWERBY WALLIS.

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February 20th, 1895.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

MRS. CHARLOTTE LYNDON, Wellington, Somerset;
ARTHUR HENRY AYLMER MORTON, M.A., Athenæum Club, S.W.;
EDWARD AMOS PEAK, Pearson Park, Hull; and
CAPT. HENRY ROBERT FREDERICK PLATER, F R.G.S., 18 Campbell Road, Bow, E., were balloted for and duly elected Fellows of the Society.

CAPT. D. WILSON-BARKER and MR. W. MARRIOTT exhibited some lantern slides showing the condition of the ice on the Thames at the date of the meeting.

The following communications were read :—

"REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1894." By EDWARD MAWLEY, F.R.Met.Soc. (p. 112.)

"THE THUNDERSTORM AND SQUALL OF JANUARY 23RD, 1895." By WILLIAM MARRIOTT, F.R.Met.Soc. (p. 102.)

"ON SOME GRADUAL WEATHER CHANGES IN CERTAIN MONTHS AT GREENWICH AND GENEVA." By ALEXANDER B. MACDOWALL, M.A., F.R.Met.Soc. (p. 108.)

CORRESPONDENCE AND NOTES.

Experiment illustrating the Formation of the Tornado Cloud.—The following experiment is so easily performed, and imitates so exactly on a small scale the mechanism of a Tornado or Waterspout, that it seems worth describing.

Obtain an old box or packing case about 2 feet square and 18 inches high. In the centre of the top cut a round hole about 3 inches diameter, and in it fix a few feet of stove pipe. Remove one side of the box, or preferably, for the sake of light, two opposite sides, and replace by window glass, leaving, however, a narrow opening on one side only between the glass and the side, about ½ inch to 1 inch broad and extending to the full height. Place in the bottom of the box a circular vessel filled with hot water, and then by any available means obtain a strong draft up the stove pipe. The characteristic funnel cloud is soon seen extending from the water to the mouth of the pipe at the top of the box, and if the draft be strong, and the conditions favourable, a decided protuberance is seen on the surface of the water just under the end of the cloud.

The draft can be obtained by burning a jet of gas in the stove pipe, and this is sufficient to form the cloud, but will hardly raise the protuberance on the water.

The success of the experiment seems to depend on a strong draft up the chimney, and on directing the air as it enters the box so that it has the greatest possible angular momentum about the centre, and also on perfectly quiet and steady conditions in the surrounding air, for the funnel when formed is easily broken up by any irregular draft.

There seems no doubt but that the cloud is formed by true dynamic cooling, as the air, saturated by the vapour from the hot water, comes under the influence of the decreased pressure at the centre; for I have not been able to form the cloud with smoke.

The circular motion and the rapid whirl are quite apparent, and can be proved by dropping any light objects into the box, also powder or soap suds floating on the water are instructive.

Probably the sizes given above are quite immaterial, but they are the first and only ones I have tried.—W. H. DINES, Oxshott, April 18th, 1895.

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Wet-bulb in Frost.—During the frost of February 1895 I made several experiments with the wet-bulb thermometer in order to see how long it would take to fall to its lowest temperature after wetting.

1. On February 8th, at 9 p.m., I applied warm water to the ordinary wet-bulb thermometer with spherical bulb, and to a sling thermometer with long cylindrical bulb which had a fringe at the upper part of the bulb (Kammerman's arrangement); the temperature of both immediately rose to 50°. At the end of 1 minute both thermometers had fallen to 32°. The sling thermometer remained at that temperature for about 1 minute, and 3 minutes later had fallen to its lowest point. The ordinary wet-bulb thermometer remained at 32° for more than 5 minutes, and fell very slowly for the first few degrees, but more quickly for the remainder. This thermometer took about 10 minutes to fall. The whole time occupied from the moment of wetting, till the actual lowest temperature was reached, was 5 minutes for the sling thermometer, and 15 minutes for the ordinary wet-bulb thermometer.

The temperature of the air at the time was 18°, the wind East, force 2, and the sky cloudless.

2. On February 11th the muslin on the ordinary thermometer was wetted at 9 p.m., but on looking at the thermometer at the end of 30 minutes the mercury in it was still 2° higher than that of the dry bulb.

The temperature of the air was 22°, the wind calm, and the sky cloudless.

3. On February 14th I experimented with three thermometers, viz. the ordinary spherical bulb, a sensitive cylindrical bulb, and the sling thermometer. On applying warm water they all rose to about 50°, and at the end of 1 minute they had fallen to 32°. The sling thermometer remained at 32° for about 5 minutes, and at the end of 8 minutes had reached its lowest point. The cylindrical bulb thermometer remained at 32° for 8 minutes, and reached its lowest point in 12 minutes. The ordinary thermometer remained at 32° for 8 minutes, and reached its lowest point in 15 minutes.

The temperature of the air was 24°, the wind East, force 2, and the amount of cloud 7.

In these experiments the sling thermometer was whirled round and round in free air, while the other thermometers were suspended in the Stevenson screen.—WILLIAM MARRIOTT.

Smoke of Volcanoes as a Weathercock.—Some of us read with interest the article on the "Great Frosts" of mediæval and recent times in the *Standard* a few days ago—qualified with a smile at the legend that "the Mediterranean twice froze over, and that carts passed over it," &c. These were of course the lagoons of Venice and kindred seas. But the writer ended by asking how these great and continued frosts arose, and it is this part of the article—unanswerable at present though it be—that makes me ask whether the finest weathercocks in the world—the smoke of its lofty volcanoes—have been properly and systematically observed? I say weathercocks, for the (smoke) vane is free to move both laterally and perpendicularly; and it is as to this latter function that I ask my question. I have long been of opinion, from reading both British and Continental works on meteorology, that the importance of "down draughts" has not received the attention due to it.

On my re-visit to Naples (after many years absence) on December 20th, 1894, I arrived during the first veering of the wind towards North after cyclonic conditions. The next morning, with the wind West, the smoke of Vesuvius, which is somewhat abundant, blew away parallel with the clouds to the east, but the day following (the 22nd) the wind was North, and the smoke made a clinging descent down the side of the mountain to, of course, south. This continued for days, *i.e.*, while the wind was North or North-east, till the 25th. On the 26th the wind was East, and the smoke did not cling so much to the mountain surface, though its descending character was strongly marked. On the morning of the 27th, with light air from the East, with the same tendency, till near noon, with a bright sun, the wind drew to the South-west, and the smoke became thoroughly uplifted to the north-east. On the 28th there was the same uplifted tendency with the same wind till the afternoon, when the wind changed to East, and immediately there was a descent of the smoke, which lasted till the morning

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of the 29th ; when, with a rapid fall of the thermometer, the wind shifted to South-south-west and an uplifted, and afterwards horizontal, course of the smoke was observable wherever the clouds in the gale admitted of observation.

Over and over again in the last two months the same thing has occurred whenever in this most extraordinarily tempestuous winter I have been able to catch a glimpse of the smoke. At the moment of writing, the wind has suddenly turned, after sirocco, with great force to the North-east, and, as seen from here, the smoke descended from the mountain, which is almost due north from here, absolutely giving the semblance of a close cling to the side of the mountain. A very long and constant acquaintance with the Alps has taught me long ago that the cold of the Swiss "bise" and Italian "tramontano" from North to North-east has nothing to do, except for a most secondary thing, with the wind's passage over the Alpine snow. Compared with the cold derived from its down draught character, this passage may be almost considered "une quantité negligeable," *e.g.* take the May of 1891 when I was, as I often have been, at Lucerne. The first part of that month was unusually hot, and the surface of the plain north of Lucerne, to distinguish them from mountains, must have been for the time of year warm, yet on a sudden change to North the wind was, as anyone might have expected, bitterly cold. While a change to South in June, travelling over 50 miles of snow and glacier, brought, as it always does at Lucerne, an intolerable heat.

My impression is that the question of descent of air, more or less (as it is), of such long continuance where in winter we have such large areas of excessive pressure is one of those that has not received the attention it deserves ; although I am, of course, quite aware of the valuable information in respect of it given in the text books. We know, *e.g.* that in the formation of hail the ascent and descent of the wind and the respective portions of the funnel shaped storm, are the factors of formation, but what here goes on in miniature goes on on a huge and lasting scale at times.—T. H. MORGAN, Sorrento, South Italy, February 16th, 1895.

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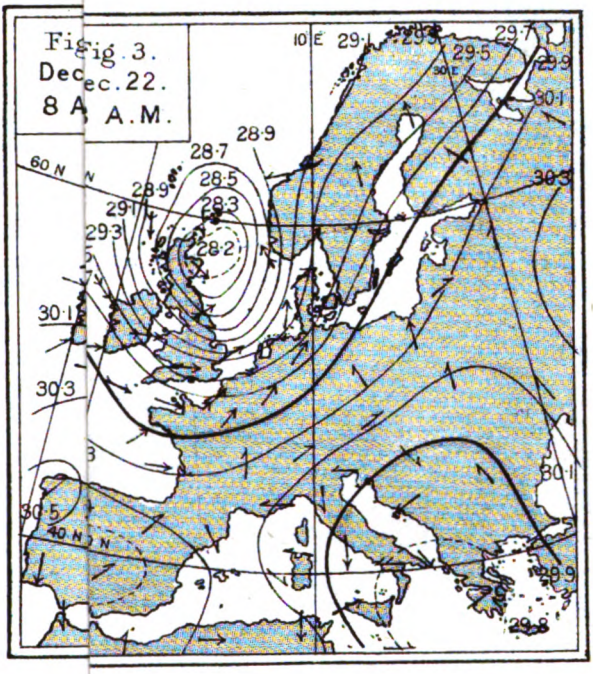

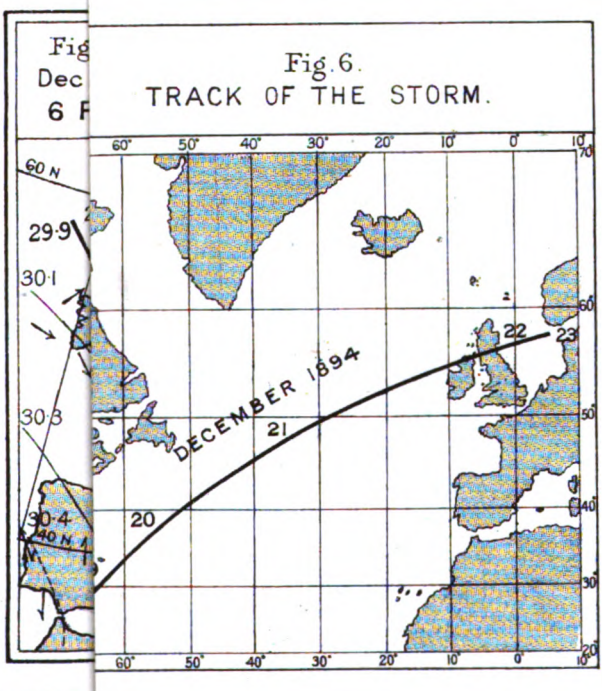

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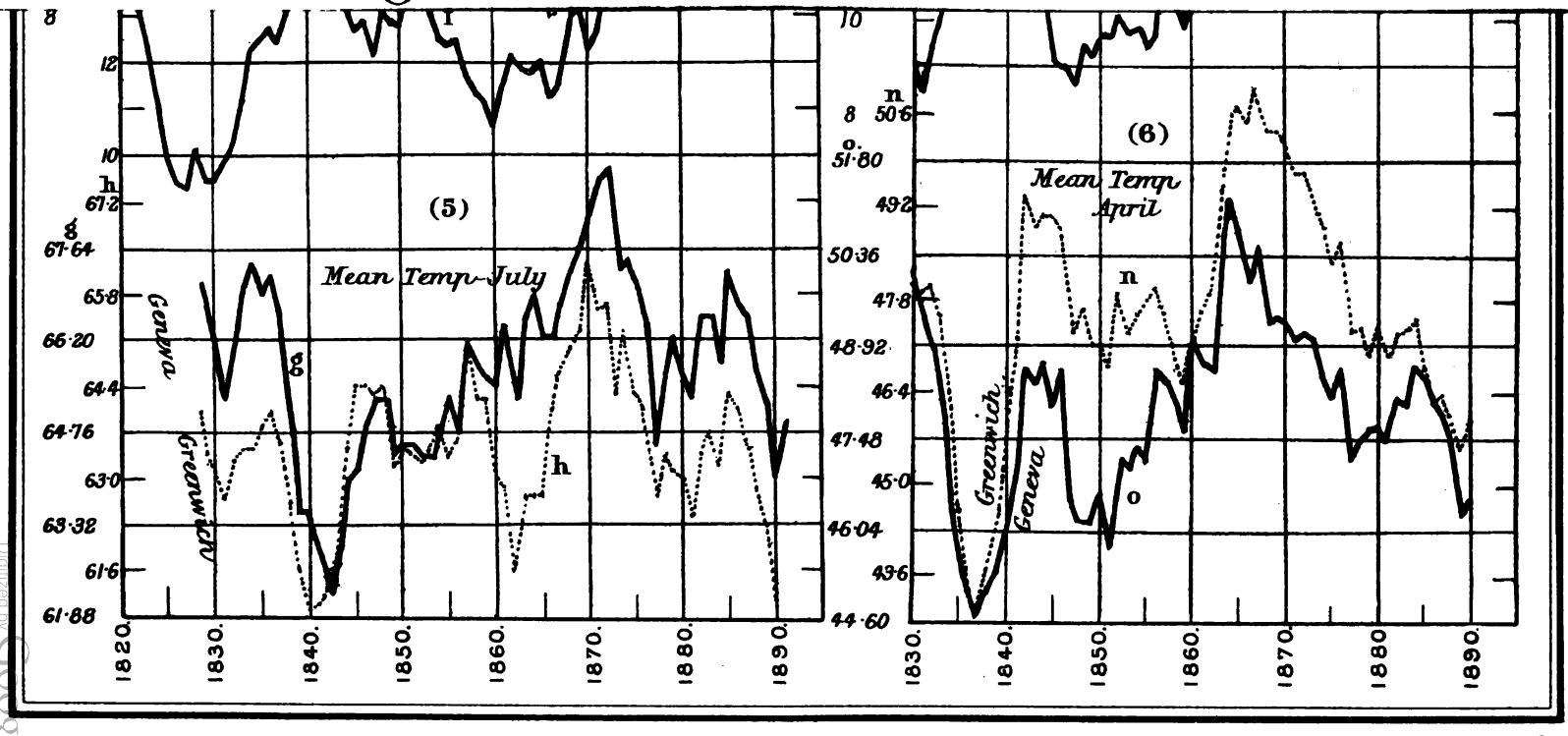

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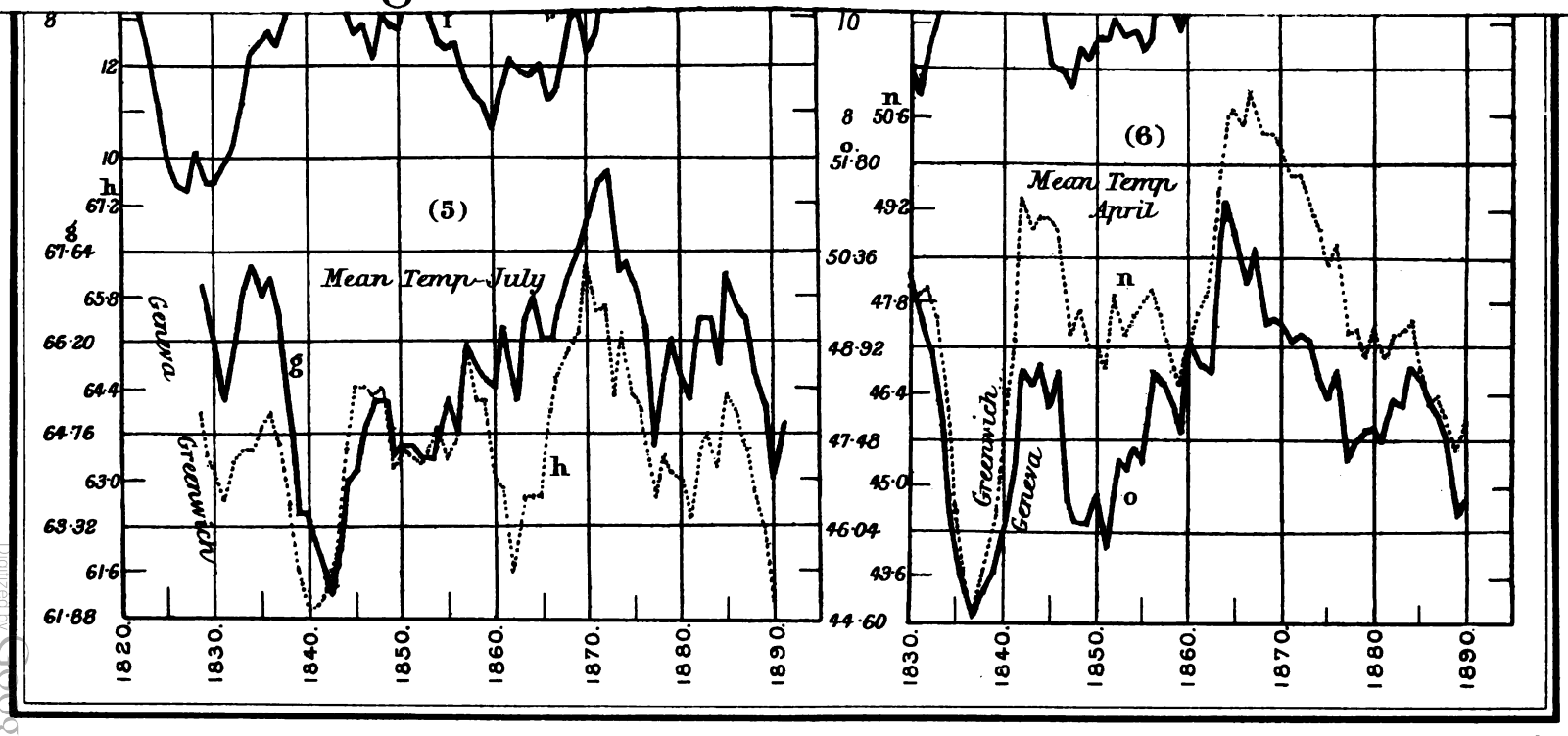

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JULY 1895.

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QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY.

VOL. XXI. JULY 1895. No. 95.

THE FROST OF JANUARY AND FEBRUARY 1895 OVER THE BRITISH ISLES.

BY F. CAMPBELL BAYARD, LL.M., F.R.Met.Soc.,

AND

WILLIAM MARRIOTT, F.R.Met.Soc.

(Plates 3-5.)

[Read April 17th, 1895.]

THE frost of January and February 1895 was of so intense a character, that it seemed desirable that a communication on the subject should be made to the Society. We have therefore willingly complied with the request of the Council to prepare such a paper, which we now submit, and trust that the information contained therein may be of interest to the Fellows.

The cold period, which commenced on December 30th, and terminated on March 5th, was broken by a week's mild weather from January 14th to 21st, otherwise the cold would have been continuous for 66 days. The character of the weather during this period will be seen at a glance from the following data for Greenwich:

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			Mean. Max.	Min.
A.	Dec. 30—Jan. 18	Cold	37·9	31·0
	Jan. 6—12	Very Cold	32·5	27·2
B.	Jan. 14—21	Mild	45·4	37·0
C.	Jan. 22—Mar. 5	Cold	35·9	24·1
	Jan. 26—Feb. 19	Intensely Cold	32·3	19·6

Minimum Temperatures.

We have plotted on maps for each day, for the whole period, the minimum temperatures from the Society's stations and also from those of the Meteorological Office, as well as some furnished by Dr. Buchan and Mr. Symons.

For the purposes of this paper we have considered a "cold day" to be when the minimum temperature has fallen below 10°. During the period in question there were 28 days on which that limit was reached in some part of the British Isles. The charts for these days are reproduced on Plates 3 and 4. The isothermal lines are drawn for each ten degrees, the areas below 10° being shaded, and those below 0° (zero) being cross shaded.

On January 8th, the temperature fell to −3° at Braemar, and was below 10° over the central part of north Scotland. Temperatures below 20° were recorded over nearly the whole of the north of Scotland, and also at several places in England and Ireland.

On the 9th, the lowest reported temperature was −5° at Braemar. Temperatures below 10° were recorded over the central part of Scotland, while readings below 20° were registered over nearly the whole of Scotland, the north and parts of the west of England, and part of Wales and Ireland.

On the 10th, the cold areas had extended and the frost had become more intense. The lowest temperatures were −2° at Braemar, and 0° at Stobo. Readings below 10° were reported from the eastern and southern parts of Scotland, and a part of the north Midlands of England and Wales. Temperatures below 20° occurred over practically the whole of Scotland, the greater part of England and Wales, and the central part of Ireland.

On the 11th, the lowest reading was 0° at Braemar. The area of temperatures below 10° extended from the north of Scotland to the Midland counties of England, while that below 20° covered nearly the whole of Scotland and England.

On the 12th, the lowest reading was 2° at Hillington, and temperatures below 10° occurred in several districts in the east of Scotland and England. Temperatures below 20° were recorded over the greater part of Scotland and England.

On the 13th, the cold had become less intense, only one station in the north of England reporting a temperature below 10°, while readings below 20° were recorded at only a few stations in the east of England.

Mild weather set in on the 14th and continued till the 21st, when the

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cold returned; and on the 26th the minimum had fallen below 10° in Wales and Norfolk, the lowest readings being 8° at Llandovery and 9° at Hillington. Temperatures below 20° occurred over the inland parts of Scotland, the north, east, and west of England, Wales, and part of Ireland.

On the 27th, temperatures below 10° were registered in the eastern and south-eastern counties, Yorkshire, and part of Wales, the lowest readings being 1° at Hillington and 8° at Geldeston. The temperature fell below 20° over almost the whole of England, Wales, and Scotland, and parts of Ireland.

On the 28th, the temperature fell below 0° in Wales, the lowest reading being −2° at Llandovery. Temperatures below 10° occurred over part of Wales, the north of England, and the west and south of Scotland; and minima readings below 20° were registered over almost the whole of England, Wales, and Scotland, as well as over the central part of Ireland.

On the 29th, temperatures below 10° were registered at several places in England, Wales, and Scotland, the lowest reading being 2° at Llandovery. Temperatures below 20° were reported from stations over nearly the whole of England and Wales, and the south and east of Scotland.

On the 30th, the temperature fell below 10° over the centre and south of Scotland, and parts of the centre of England, the lowest readings being 1° at Braemar and 8° at Stobo. Temperatures below 20° occurred over nearly the whole of Scotland, England, and Wales.

On the 31st, temperatures below 10° were registered over the central and southern parts of Scotland and part of Wales, the lowest readings being 2° at Braemar and 4° at Stobo. The temperature fell below 20° over nearly the whole of Scotland, the north and west of England, the greater part of Wales, and the south-west of Ireland.

From February 1st to 4th the cold was not so severe, the minimum temperature at no place being below 10°.

On the 5th, temperatures below 10° were registered over Wales and parts of the centre of England, the lowest reading being 5° at Gwernyfed Park, Brecknockshire. The minima fell below 20° over the greater part of England and Wales, and at a few stations in Scotland.

On the 6th, temperatures below 0° were registered at several places in the Midland districts of England, the lowest readings being −4° at Barkby, −3° at Ketton, and −2° at Bury St. Edmunds. The minima fell below 10° over the whole of the midland and part of the south-western districts of England, and part of Wales and Ireland; and also below 20° over the whole of England and Wales, and the greater part of Scotland and Ireland.

On the 7th, temperatures below 0° were registered at several places in England, Scotland, and Ireland, the lowest readings being −10° at Barkby, −7° at Aviemore, Inverness-shire, and −4° at Ketton. Temperatures below 10° occurred over the greater part of England and Wales, the centre and south of Scotland, and the centre of Ireland; while the isothermal line of 20° embraced almost the whole of the British Isles.

On the 8th, temperatures below 0° were registered over the centre and

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south of Scotland, the north, centre, and other parts of England and Wales, the lowest readings being −13° at Aviemore, and −12° at Braemar. The area of temperatures below 10° embraced almost the whole of Scotland and England except the west and south, and also part of the centre of Ireland. Temperatures below 20° occurred over the whole of Scotland, Wales, and England (except the extreme south-west coast), and the greater part of Ireland.

On the 9th, temperatures below 0° were registered over the centre and south of Scotland, the north and midland districts of England, and part of Wales, the lowest readings being −11° at Braemar and Aviemore, −9° at Glenlee, and −8° at Blair Athol. The area of temperatures below 10° was similar to that of the previous day, and embraced almost the whole of Scotland, England, and Wales, except the west and south, and also part of the centre of Ireland. Temperatures below 20° occurred over the whole of Scotland, Wales, and England (except the south-west coasts), and the north-east of Ireland.

On the 10th, temperatures below 0° were registered over the centre and south of Scotland, the north, centre, and east of England, and part of Wales, the lowest readings being −14° at Braemar, −13° at Blair Athol, and −11° at Drumlanrig. The area of temperatures below 10° embraced nearly the whole of Scotland and the north, east, and centre of England, and part of Wales. Temperatures below 20° occurred over the whole of Scotland, nearly the whole of England and Wales, and parts of Ireland.

On the 11th, temperatures below 0° were registered over the central and southern parts of Scotland, and in Derbyshire, the lowest readings being −17° at Braemar, and −11° at Buxton. Temperatures below 10° occurred over the greater part of Scotland, and the north, east, and midland districts of England, and below 20° over the whole of Scotland, the greater part of England, and also in Wales and Ireland.

On the 12th, temperatures below 0° were registered over the south of Scotland, the lowest reading being −8° at Drumlanrig. Temperatures below 10° occurred over the north, centre, and south of Scotland, the north, east, west, and other parts of England, Wales, and parts of Ireland. The area of temperatures below 20° embraced almost the whole of the British Isles.

On the 13th, temperatures below 0° were registered over the centre and south of Scotland, the lowest reading being −7° at Braemar. Temperatures below 10° occurred over the central and southern parts of Scotland, the greater part of England and Wales, and the centre of Ireland. The area of temperatures below 20° embraced almost the whole of Scotland, England, and Wales, and parts of Ireland.

On the 14th, the lowest minimum reported was −7° at Drumlanrig. Temperatures below 10° occurred over parts of Scotland and England; and the isothermal line of 20° embraced almost the whole of Scotland, England, and Wales.

On the 15th, temperatures below 10° were reported from Leicestershire and the south of Scotland, the lowest being 8° at Loughborough. Tempera-

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tures below 20° occurred in the north and south of Scotland and the greater part of England and Wales.

On the 16th, the temperature fell to −11° at Aviemore, and was below 10° over the centre and south of Scotland. Temperatures below 20° occurred over the greater part of Scotland, and several parts of England and Wales.

On the 17th, the temperature fell to −11° at Aviemore, and −9° at Braemar, and was below 10° over the central parts of Scotland, and the east and south-east of England. Temperatures below 20° occurred over nearly the whole of Scotland, and most of the southern half of England, and part of Wales.

On the 18th, the temperature fel to −11° at Aviemore, and −7° at Braemar, and was below 10° over the central part of Scotland. Temperatures below 20° occurred over the greater part of Scotland and England, and parts of Wales and Ireland.

On the 19th, the temperature fell to −8° at Aviemore and Braemar, and was below 10° over the central and southern parts of Scotland. Temperatures below 20° occurred over almost the whole of Scotland, and at several places in England and Ireland.

On the 20th, the temperature fell to −5° at Braemar, and 0° at Drumlanrig, and was below 10° over the central and southern districts of Scotland. Temperatures below 20° occurred over nearly the whole of Scotland, the north-west and other parts of England, Wales, and the north-west of Ireland.

After this date no readings below 10° were recorded, although frost occurred on every day, during the remainder of the cold period, in some part of the British Isles.

Mean Temperatures.

Table I. gives the mean maximum and minimum temperatures at a number of stations for January and February; for the period of intense cold, January 26th to February 19th; and also for the whole period, December 30th to March 5th.

On Plate 5 are given charts of mean temperature for January and February, and also for comparison Dr. Buchan's charts of the average temperature for the period 1857-1880. From these charts it will be seen that the mean temperature of the British Isles for January was about 7°, and for February was from 11° to 20°, below the average.

On Plate 5 are also given the charts of mean temperature for the whole period, December 30th to March 5th; and for the period of intense cold, January 26th to February 19th.

Table II. gives the number of times during January and February the maximum temperature was 32° or below, 25° or below, and the lowest reading; as well as the number of times the minimum temperature was 20° or below, 10° or below, and the lowest reading.

The intensity of the frost may be gathered from the fact that there were 19 days on which the temperature fell below 0°, and 28 days on which it was below 10°, in some part of the British Isles.

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TABLE I.—MEAN MAXIMUM AND MINIMUM TEMPERATURES.

Station.	January.		February.		Jan. 26 to Feb. 19.		Dec. 30 to March 5.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
SCOTLAND, N.	°	°	°	°	°	°	°	°
Sumburgh Head	37·7	31·3	37·5	29·0	35·6	26·8	37·5	29·9
Deerness	37 6	30·9	36·8	29·8	34·9	27·9	37·2	30·0
Stornoway	38·7	29·6	41·1	27·4	38·9	24·6	39·7	28·6
Scourie	40·5	27·8	39·9	24·1	37·7	21·2	40·2	26·0
Wick	37·5	27·8	37·4	24·0	35·4	21·2	37·4	26·2
Glencarron	35·2	23·9	35·2	22·6	32·2	18·4	35·4	23·4
Fort Augustus	36·1	23·5	36·9	21·6	33·8	17·5	36·6	23·0
Fort William	37·3	27·2	37·0	25·1	33·9	21·8	37·3	26·6
SCOTLAND, E.								
Nairn	36·2	24·7	36·7	17·3	33·7	12·5	36·5	21·9
New Pitaligo...	35·1	25·3	35·2	21·8	33·8	18·4	35·2	23·8
Aberdeen	36·1	27·0	35·4	22·9	32·6	19·9	36·0	25·5
Logie Coldstone	33·4	22·4	32·3	19·4	29·1	15·2	33·1	21·4
Braemar	31·6	18·0	30·6	12·3	27·1	6·9	31·3	16·1
Fettercairn	36·1	25·1	36·5	19·3	33·7	16·2	36·6	22·9
Montrose	35·0	26·0	35·3	22·5	32·6	19·9	35·5	24·6
Lednathie	34·0	21·7	35·1	17·1	32·1	13·6	34·6	20·1
Ochtertyre	35·8	24·8	38·9	21·7	35·3	18·5	37·6	23·8
Stronvar	34·0	21·3	37·0	18·5	32·8	15·6	35·7	20·6
Dollar	35·6	27·5	35·4	24·1	33·4	22·6	35·9	26·3
Leith	37·5	27·1	38·5	24·8	35·6	22·2	38·4	26·5
Edinburgh	36·2	27·5	37·1	25·4	34·0	22·9	37·0	26·9
Marchmont	35·1	25·3	34·2	24·1	31·7	21·1	34·6	25·0
Stobo...	34·4	18·7	33·2	15·8	29·7	12·1	34·5	18·0
Hawick	34·0	22·5	34·5	20·5	31·6	17·4	34 8	22·1
ENGLAND, N.E.								
Alnwick	36·0	27·9	35·1	25·4	32·6	23·5	35·7	27·0
North Shields	37·6	27·5	36·9	25·5	34·3	23·6	37·5	26·8
Durham	35·1	25·4	35·8	23·3	33·1	20·3	35·8	24·7
Aysgarth	33·2	24·7	33·0	21·6	29·9	19·0	33·3	23·6
Scarborough	37·7	28·7	36·7	27·0	33·6	24·8	37·9	28·1
York	36·3	26·2	36·4	22·9	33·6	20·0	36·7	25·0
Spurn Head	37·9	30·8	35·6	28·8	33·9	26·8	36·9	29·8
ENGLAND, E.								
Hillington	36·6	24·8	35·6	21·5	32·8	16·6	36·4	23·8
Yarmouth	37·5	28·8	34·8	26·9	32·6	23·6	36·4	28·0
Geldeston	38·6	26·8	36·3	22·8	34·3	18·9	37·9	25·2
Cambridge	37·3	26·8	36·9	20·7	33·8	16·5	37·5	24·3
Rothamsted	36·5	27·3	34·3	20 6	31·1	16·4	35·8	24·6
MIDLAND COUNTIES.								
Healey Hall, Bawtry	36·2	25·9	36·6	20·5	33·5	16·4	36·7	23·9
Belvoir Castle	35·4	25·0	34·4	20·1	31·7	16·1	35·3	23·3
Loughborough	36·9	25·8	36·6	17·3	33·7	12·2	37·1	22·5
Ketton	36·7	26·1	36·4	17·5	33·2	13·3	37·0	22·8
Cheadle	34·9	25·5	33·8	23·0	30·9	20·1	34·8	24·7
Solihull	35·1	26·9	33·9	20·9	30·9	17·4	34·9	24·6
Churchstoke	35·7	24·1	33·6	18·9	30·9	15·2	35·1	22·2
Burghill	37·0	27·5	34·9	19·3	32·1	15·9	36·5	24·2
Cirencester	37·4	26·3	33·7	21·1	30·7	17·4	36·0	24·2
Oxford	37·4	28·6	35·4	21·6	32·4	18·3	36·8	25·6
ENGLAND, S.								
London (Brixton)	38·2	29·9	35·6	23·0	32·6	19·8	37·3	26·9
Greenwich	37·7	29·5	35·2	22·8	32·3	19·6	36·9	26·7
Cooper's Hill	37·3	28·9	33·8	22·8	31·0	19·6	36·1	26·3

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TABLE I.—MEAN MAXIMUM AND MINIMUM TEMPERATURES—*Continued.*

Station.	January.		February.		Jan. 26 to Feb. 19.		Dec. 30 to March 5.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
ENGLAND, S.—*Continued.*								
North Foreland	38·9	30·5	34·3	26·1	32·5	23·7	36·8	28·6
Strathfield Turgiss	37·7	27·9	36·2	19·1	33·0	16·4	37·4	24·1
Dungeness	38·9	30·1	34·9	23·7	32·7	21·3	37·0	27·1
St. Leonard's	38·4	30·3	34·3	25·8	31·7	23·5	36·6	28·2
Southampton	39·8	29·9	37·5	23·9	34·5	21·4	39·1	27·4
Hurst Castle	40·1	31·5	35 9	25·5	33·9	23·6	38·5	28·8
Stowell	37·7	27·3	33·9	21·7	31·6	18·5	36·3	25·0
SCOTLAND, W.								
Laudale	38·9	26·9	37·7	25·1	34·4	23·2	38·7	26·2
Duntreath	35·8	...	37·2	22·2	33·2	...	37·0	...
Glasgow	35·6	27·5	35·5	24 6	32·3	22·2	35·9	26·6
Ardrossan	37·3	28·8	37·5	25·5	34·1	23·0	37·8	27·8
Drumlanrig	37·6	24·5	37·1	15·8	34·8	13·8	37·7	21·1
Glenlee	35·4	24·3	34·1	18·1	31·5	15·7	35·3	22·1
Cronkbourne, Isle of Man	39·4	31·6	38·1	26·9	35·9	26·2	38·9	29·6
ENGLAND, N.W.								
Hawes Junction	31·9	21·5	30·3	19·0	27·7	16·3	31·3	20·5
Stonyhurst	35·0	27·4	34·1	24·3	31·6	21·8	34·9	26·3
Blackpool	38·4	26·9	35·8	22·7	34·3	20·0	37·5	25·5
Prestwich	36·6	26·4	35·1	23·1	32·7	20·9	36·4	25·1
Bidston	36·9	29·8	34·5	25·0	32·4	23·1	36·1	28·0
Llandudno	39·3	32·2	36·2	27·3	34·4	25·3	38·1	30·2
Holyhead	40·5	33·3	37·2	28·3	35·6	26·7	39·2	31·2
ENGLAND, S.W.								
Llandovery	37·7	23·9	36·2	18·4	33·0	14·5	37·4	21·8
St. Ann's Head	41·8	34·8	37·0	27·9	35·3	26·6	39·7	31·8
Bristol	38·6	29·5	35·5	22·2	32·9	19·3	37·8	26·5
Arlington	38·6	29·0	33·5	22·9	31·3	20·7	36·5	26·5
Cullompton	39·8	28·3	36·1	22·7	33·9	20·2	38·5	26·4
Prawle Point	42·2	31·9	37·3	28·6	35·5	26·8	40·1	30·4
Plymouth	41·3	31·8	38·0	28·6	36·0	26·1	40·0	30·5
Falmouth	42·8	33·8	38·2	30·6	36·8	28·4	41·0	32·5
IRELAND, N.								
Malin Head	40·6	34·1	38·5	31·5	36·7	29·4	39·7	33·0
Londonderry	39·0	30·1	39·7	26·4	37·2	24·8	39·5	28·8
Edenfel (Omagh)	36·6	28·5	36·4	22·8	33·8	21·3	36·8	26·2
Belmullet	42·5	34·4	39·7	29·8	37·8	29·2	41·5	32·5
Markree	39·4	28·7	38·8	23·9	35·8	22·7	39·6	26·8
Colebrooke	40·3	27·5	38·8	22·6	36·8	21·2	39·6	25·6
Arley Cottage (Lough Sheelin) ...	37·3	27·8	37·4	23·7	34·7	23·3	37·8	26·2
Currygrane	37·2	27·7	37·0	23·0	34·3	21·6	37·5	25·9
Armagh	37·2	27·6	37·6	24·3	35·1	22·7	37·7	26·4
Donaghadee	40·3	32·5	39·0	29·4	36·7	28·4	39·9	31·2
IRELAND, S.								
Dublin	39·6	31·2	38·4	29·9	36·6	29·1	39·2	30·7
Parsonstown	38·9	28·8	38·1	23·9	35·9	23·0	38·8	26·9
Kilkenny	39·3	29·2	38·1	27·3	36·0	26·4	39·1	28·6
Roche's Point	43·6	34·4	41·4	32·4	39·9	32·4	42·8	33·7
Foynes	41·3	31·7	39·3	29·1	37·7	28·2	40·7	31·0
Killarney	43·7	31·4	40·6	28 2	39·2	29·1	42·7	30·1
Valencia	44·1	35·1	42·0	32·0	40·7	32·2	43·5	34·1
CHANNEL ISLANDS.								
Scilly	46·0	38·3	40·5	33·5	39·8	32·7	43·6	36·2
Jersey	43·5	34·9	35·6	27·3	34·0	25·9	40·0	31·7

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TABLE II.—Particulars of Maximum and Minimum Temperatures during January and February 1895.

Station.	Maximum.						Minimum.					
	January.			February.			January.			February.		
	32° or below.	25° or below.	Lowest.	32° or below.	25° or below.	Lowest.	20° or below.	10° or below.	Lowest.	20° or below.	10° or below.	Lowest.
Scotland, N.			°			°			°			°
Sumburgh Head ...	3	...	29·0	4	1	25·0	...	...	22·2	2	...	17·0
Deerness	3	...	29·8	4	...	28·0	...	...	23·0	...	...	20·6
Stornoway	3	...	31·0	1	...	31·0	1	...	19·0	2	...	16·0
Scourie	1	...	30·0	2	...	30·0	3	...	20·0	13	...	14·0
Wick	3	...	32·0	3	...	28·0	4	...	14·0	9	3	2·0
Glencarron	7	1	24·5	7	3	23·2	9	1	9·1	10	1	8·6
Fort Augustus ...	6	1	24·0	6	...	26·3	11	3	4·9	13	5	4·2
Fort William ...	5	1	24·5	7	...	27·2	4	...	10·8	10	...	11·0
Scotland, E.												
Nairn	3	...	26·0	7	...	26·0	10	3	5·0	15	12	0·0
New Pitsligo... ...	3	...	26·9	5	...	26·8	9	...	14·2	11	...	10·6
Aberdeen	7	...	25·4	7	2	19·0	6	1	9·9	12	5	5·6
Logie Coldstone ...	13	1	25·0	10	4	15 3	10	3	5·2	13	7	− 3·0
Braemar	14	4	18·2	16	6	14·0	13	8	−5·0	14	12	−17·0
Fettercairn	3	...	26·7	6	1	24·7	7	4	6·0	13	11	− 3·0
Montrose	7	...	26·6	6	2	22·6	4	...	12·3	11	4	3·3
Lednathie	9	2	21·5	8	2	21·0	13	5	5·0	14	11	− 3·0
Ochtertyre	4	1	22·0	6	1	24·0	8	1	10·0	13	5	4·0
Stronvar	9	4	17·0	8	1	24·0	12	5	4·0	15	9	2·0
Dollar	3	1	25·0	8	1	25·0	4	...	14·0	9	..	11·0
Leith	2	...	29·0	4	...	28·0	6	...	15·0	9	...	12·0
Edinburgh	3	...	29·8	6	1	24·5	3	...	19·0	9	...	13·9
Marchmont	7	...	30·0	8	2	11·0	8	...	14·0	10	2	7·0
Stobo...	13	2	20·0	13	6	20·0	16	8	0·1	16	8	0·0
Hawick	9	2	20·0	7	4	18·8	9	4	2·1	11	6	− 0·1
England, N.E.												
Alnwick	6	...	26·0	9	2	23·0	3	...	11·0	9	2	4·0
North Shields ...	3	...	28·0	7	1	24·0	3	...	13·0	9	4	7·0
Durham	6	...	27·7	6	2	24·7	7	3	8·4	8	5	− 1·8
Aysgarth	9	1	24·0	9	4	21·4	7	...	10·1	10	5	− 2·1
Scarborough ...	4	...	26·3	4	3	21·3	1	...	18·4	5	1	8·1
York	5	...	27·0	8	1	23·0	7	...	12·0	9	4	3·0
Spurn Head	2	...	31·0	5	...	26·0	...	...	23·0	2	...	20·0
England, E.												
Hillington	6	...	28·1	6	...	25·3	8	3	1·9	10	6	1·1
Yarmouth	1	...	29·0	9	1	25·0	3	...	11·0	4	...	15·0
Geldeston	1	...	29·1	6	1	25·0	5	1	8·0	9	3	1·4
Cambridge	4	...	28·2	5	...	26·6	7	...	15·0	13	5	5·5
Rothamsted	8	...	26·2	9	2	22·8	4	...	14·5	14	4	2·5
Midland Counties.												
Hesley Hall, Bawtry	5	...	30·0	6	2	23·0	8	1	9·0	13	7	− 1·0
Belvoir Castle ...	8	1	25·0	10	2	24·0	11	2	10·0	12	6	− 3·0
Loughborough ...	6	1	24·0	7	...	26·4	7	2	9·0	13	11	− 5·0
Ketton	5	...	30·0	7	...	26·0	7	...	12·0	14	9	− 8·0
Cheadle	8	...	27·4	9	2	24·5	6	...	15·0	10	...	11·2
Solihull	10	1	21·3	11	2	22·3	7	...	11·3	11	4	0·5
Churchstoke... ...	5	...	27·5	12	2	23·4	9	1	9·6	15	5	0·2
Burghill	6	...	28·5	8	1	21·6	5	...	16·0	12	7	− 3·2
Cirencester	7	...	28·0	11	2	24·0	9	...	11·0	13	6	6·0
Oxford	8	1	24·0	8	2	24·0	6	...	13·0	13	4	7·0
England, S.												
London (Brixton) ...	5	...	30·0	9	1	24·0	1	...	18·0	12	1	10·0
Greenwich	6	...	28·7	11	...	27·0	...	...	20·3	11	2	6·9
Cooper's Hill ...	6	...	26·9	11	2	23·4	1	...	19·1	13	...	10·1

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TABLE II.—PARTICULARS OF MAXIMUM AND MINIMUM TEMPERATURES DURING JANUARY AND FEBRUARY 1895—*Continued.*

Station.	Maximum.						Maximum.					
	January.			February.			January.			February.		
	32° or below.	25° or below.	Lowest.	32° or below.	25° or below.	Lowest.	20° or below.	10° or below.	Lowest.	20° or below.	10° or below.	Lowest.
			°			°			°			°
ENGLAND, S.—*Cont.*												
North Foreland ...	...	...	33·0	12	1	24·0	...	...	22·0	5	...	18·0
Strathfield Turgiss ...	7	...	27·0	7	...	25·3	2	...	19·1	13	5	1·8
Dungeness	2	...	30·0	9	1	25·0	1	...	19·0	10	...	13·0
St. Leonard's ...	3	...	28·2	12	2	23·2	...	...	21·9	...	...	20·3
Southampton ...	3	...	27·6	5	...	26·3	1	...	19·1	6	...	13·7
Hurst Castle ...	2	...	32·0	6	...	27·0	1	...	20·0	4	...	17·0
Stowell	9	...	26·6	11	1	23·5	4	...	13·6	13	1	9·5
SCOTLAND, W.												
Laudale	4	...	27·0	6	...	25·9	4	...	16·0	7	...	16·8
Duntreath	7	·2	19·0	7	2	23·0	?	?	?	12	5	6·0
Glasgow	4	1	23·9	8	3	22·3	3	...	15·0	7	1	6·6
Ardrossan	2	...	32·0	6	3	22·0	2	...	19·0	6	...	13·0
Drumlanrig	1	...	29·4	7	...	25·4	7	1	8·0	14	8	−11·0
Glenlee	6	...	29·0	11	4	16·2	10	...	12·0	14	8	− 5·0
Cronkb'ne, I. of Man	...	...	34·9	3	...	28·0	...	...	20·5	4	...	10·5
ENGLAND, N.W.												
Hawes Junction ...	16	1	25·0	16	6	19·0	13	1	8·0	14	4	3·0
Stonyhurst	7	...	27·5	10	4	23·7	3	...	18·9	8	...	10·5
Blackpool	2	...	27·6	6	1	23·3	7	...	12·0	12	2	9·9
Prestwich	4	...	29·8	7	2	21·8	7	...	16·9	10	...	10·6
Bidston	6	...	27·0	8	2	22·0	...	...	22·0	7	...	12·0
Llandudno	...	...	33·0	6	...	25·5	...	...	24·8	4	...	17·5
Holyhead	...	...	33·0	4	...	27·0	...	...	28·0	2	...	17·0
ENGLAND, S.W.												
Llandovery	5	...	27·0	9	...	26·0	10	3	−2·0	15	5	3·0
St. Ann's Head ...	1	...	30·0	5	...	29·0	...	...	27·0	...	...	23·0
Bristol	3	...	27·7	7	...	25·8	2	...	18·0	12	...	10·5
Arlington	4	...	28·0	11	1	23·0	3	...	16·0	9	...	13·0
Cullompton	1	...	28·4	6	...	25·8	3	...	15·6	7	...	11·3
Prawle Point ...	1	...	32·0	4	...	29·0	...	...	25·0	...	...	21·0
Plymouth	...	...	34·0	2	...	29·6	...	...	22·0	1	...	19·0
Falmouth	...	...	34·8	1	...	31·5	...	...	25·4	...	...	22·3
IRELAND, N.												
Malin Head	...	...	34·0	5	...	30·0	...	...	27·0	1	...	20·0
Londonderry... ...	1	...	32·0	1	...	31·5	...	...	23·0	5	...	14·5
Edenfel (Omagh) ...	7	...	31·0	7	...	28·0	3	...	19·0	9	2	5·0
Belmullet	...	...	36·0	3	...	30·0	...	...	29·0	...	...	23·0
Markree	1	...	31·0	2	...	30·0	2	...	16·3	5	2	1·6
Colebrooke	...	...	33·0	2	...	30·0	5	...	14·2	10	4	− 2·0
Arley Cottage (Lough Sheelin) ...	1	...	30·8	4	...	28·8	4	...	16·1	6	2	2·0
Currygrane	3	...	31·0	5	...	27·0	3	...	18·5	5	3	0·0
Armagh	2	...	30·5	3	...	29·0	4	...	12·2	7	2	4·9
Donaghadee ...	...	...	35·0	3	...	30·0	...	...	25·0	5	...	16·0
IRELAND, S.												
Dublin	1	...	30·8	1	...	30·7	1	...	16·9	1	...	19·0
Parsonstown ...	...	...	32·5	3	...	29·5	3	...	19·3	4	3	6·0
Kilkenny	2	...	31·0	2	...	31·0	3	...	18·0	3	...	11·0
Roche's Point ...	...	...	36·0	...	...	36·0	...	...	27·0	...	...	25·0
Foynes	1	...	31·8	...	..	33·4	...	...	24·1	1	...	17·3
Killarney	...	...	37·0	...	...	33·0	3	...	19·5	4	...	14·5
Valencia	...	...	37·0	...	...	36·0	...	...	28·0	...	...	22·0
CHANNEL ISLANDS.												
Scilly	...	...	36·0	...	...	36·0	...	...	28·0	...	...	27·0
Jersey	...	...	35·0	6	...	25·1	...	...	26·1	2	...	18·1

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Atmospheric Pressure.

During the period under review the distribution of atmospheric pressure over the British Isles was almost entirely the reverse of the normal. The pressure in January was lowest in the south, and highest in the north, the conditions being favourable for strong Northerly and Easterly winds. In February the conditions were more decidedly anticyclonic, but still the pressure was low in the south, the result being that the general direction of the wind was from the North-east or East.

It was owing to the persistent winds that prevailed during nearly the whole of this period that there was but little, if any, fog. This was one of the most remarkable features of the recent frost, as former frosts have almost invariably been accompanied with quiet anticyclonic conditions and consequently much fog.

Snow fell in the north on several occasions, and owing to the strong winds which blew at the time heavy snowdrifts occurred, which in many instances in Scotland completely blocked the railways. On February 8th a heavy fall of snow occurred over the north of Ireland and the Isle of Man, the melted snow at Donaghadee producing 1·59 in. of water.

Death Rate.

The effect of the cold on the public health was very great, especially on young children and old people. The total number of deaths in London was below the average till the week ending February 2nd, after which they rose with great rapidity until March 9th, when the registered number of deaths for that week was 3,471, or 1,583 above the average—the death rate being 41·2 per thousand. After this the number of deaths rapidly decreased, and by March 30th had almost fallen to the average. The dotted line shows the average death rate. (Fig. 1.)

The number of deaths due to diseases of the respiratory organs rapidly increased from February 2nd to March 2nd, when they were 1,448, or 945 above the average. They were slightly less during the next week, after which they declined to about the average by the end of the month. (Fig. 1.)

The number of deaths according to ages is shown in Fig. 2; from which it will be seen that there was comparatively little effect of the cold on people in vigorous health—that is between 5 and 40 years of age. The effect on middle aged people—that is between 40 and 60—was very pronounced, the deaths rising from 324 on February 2nd to 669 on March 9th. Children under 5 years of age suffered severely, the deaths rising from 462 on January 26th to 1,013 on March 9th. The effect of the cold on old people—that is above 60 years of age—was most remarkable, the number of deaths rising from 437 on February 2nd to 1,331 on March 2nd, and 1,368 on March 9th; being an increase of more than three times the number in four weeks.

Skating.

As a result of the frost, rivers, lakes, ponds, &c., all became fast bound in ice, and afforded ample scope for skating. In Regent's Park skating was

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permitted on the lake from January 9th to 18th, and from the 29th to March 8th,—in all a period of 44 days. The ice was 10 inches thick on February 18th.

The Serpentine in Hyde Park is not thrown open for skating so much as formerly, as the authorities will not allow the public to go on the ice until it

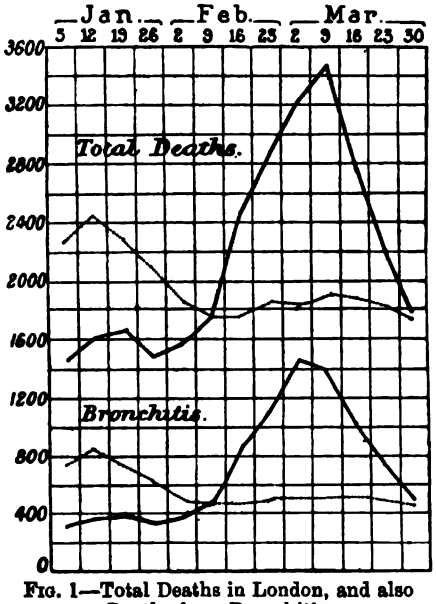

FIG. 1.—Total Deaths in London, and also Deaths from Bronchitis.

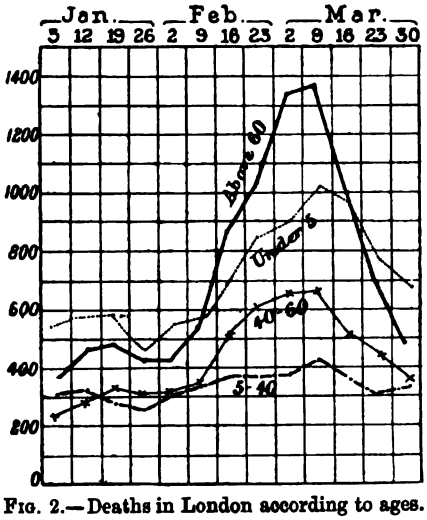

FIG. 2.—Deaths in London according to ages.

has attained a considerable thickness. There was skating on the Serpentine from February 8th to 21st. The ice was 7½ inches thick on the 19th and 20th.

Vast numbers of people skated not only on the lakes in the London Parks, but also on all sheets of water all over the country. The railway companies ran special trains for skaters to Lake Windermere and Loch Lomond. The following extract from *The Westmoreland Gazette*, February 16th, will give some idea as to the enthusiasm with which skating was taken up:—

> The lakes, chief among them Windermere, have been fast bound in ice. On Monday morning Windermere was one sheet of black ice, contrasting in this respect with most, if not all, of the other lakes, where the ice was spoilt by snow. The news of the freezing of the lake soon spread, and during the present week Windermere has been visited by thousands of skaters, as well it might, considering that the opportunity of skating over between three and four thousand acres of ice does not occur more than twice or thrice in a lifetime. That Bowness should be the great skating centre was inevitable, from its proximity to the railway station at Windermere and its accessibility to a considerable local population. Since Saturday the shore and the surface of the lake have presented a scene of the greatest animation. Troops of well dressed folk, carrying skates, have hurried down from the station, the crowds increasing as the week progressed. On Wednesday, when there were cheap bookings from Liverpool and Manchester, and a special train from Lancaster, the number of persons on the lake could not have been less than 2,000. The Bowness Urban District Council early took measures tending to the preservation of skaters from

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risk, and their rescue in the event of accident. Ropes and ladders were deposited at various points along the shore; two men were appointed to keep watch, and at places where there were signs of weak ice, flags were planted. A row of flags was fixed along the north side of the track kept open by the ferry boat, which has plied to and fro as usual. Skaters wishing to get past Ferry Nab had to cross a small portion of the shore in order to do so. At a dangerous bit near Henholme a red lamp was put up to warn off skaters who ventured near after dark. Bonfires were lighted in front of the promenade, and Mrs. Richards, with her characteristic thoughtfulness, had a tall electric lamp put up on the lawn of the Old England Hotel. The boatmen were enabled to make a little money by putting on and taking off skates, using their cushion-houses for the purpose. Refreshments were served out on the ice, and two or three photographers were employed at intervals in "taking" groups of skaters. A brass band has been stationed on one of the islands, and to its strains many of the skaters have indulged in waltzing. On Wednesday, Mr. Geo. H. Pattinson, chairman of the Urban Council, drove across the ice in a sledge to the shore of Belle Isle. His example was afterwards followed, and his performance improved upon by a man in the employ of Mr. John Crosthwaite, who, with two other gentlemen, drove tandem over the ice. As night draws on, the skaters, of course, get fewer, but some of the more ardent, desirous perhaps of enjoying the novelty and charm of skating by moonlight, have skated far into the night. To such, the scene and the situation must have been of an impressive kind. The ice, smooth and clear, reflects the whitened hills like a mirror, and the echo of the ringing steel imparts a solemnising effect.

Mr. R. Waters, writing from Bowness on March 16th, said: "The lake is still covered with thick ice, with only here and there an open space. A gentleman skated from Bowness boat-landings to Henholme on Wednesday last, March 13th."

In the Fen district the ice was in some places 2 feet thick.

At Oxford a coach and six was driven over the Cherwell. (A photograph of this was shown to the meeting on the screen.)

On the Grand Junction Canal traffic was stopped for 32 days, although the ice boats, which are able to break and make a fair way through ice 7 to 8 inches thick, were kept running as long as possible.

Ice on the Thames.

Capt. D. Wilson-Barker, of H.M.S. *Worcester*, off Greenhithe, has supplied the following notes as to the ice on the Thames:—

"The ice floes began to accumulate at Greenhithe (18 miles below London) on February 7th, and daily got thicker until, on the 9th, nearly all communication, except for an hour or two at the top of high water, was completely cut off; and it was only by means of a hawser, rigged to the shore from the main topmast head, that we could get our mails off.

"From the 9th to the 17th the whole river was more or less completely blocked with ice, and there was little traffic, it being quite impossible for full-powered steamers to force their way up or down except with the tide. Barges were floating about adrift in all directions, and the ice floes were 6 and 7 feet, and even more, thick. But the ice was generally soft and brashy, and it is likely that much of it was due to the cartloads of snow which were shot into the river in London, and which from lying in the carts had become more or less compacted together, and practically went into the river as a semi-solid lump.

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"The tides appeared to have been affected to a certain extent, and to have been somewhat irregular.

"In 1881, from about January 22nd to 29th, the river presented a somewhat similar spectacle, but the quantity of ice was not so great, and communication with the shore was much better kept up."

Earth Temperatures.

Table III. gives the lowest observed readings of the earth thermometers at the Society's stations from 3 inches to 2 feet below the surface. From this it will be seen that at the majority of the stations the temperature at 1 foot did not fall much below 32°. Three stations, however, report temperatures at 1 foot of nearly 28°, viz. Aspley Guise, Lowestoft, and Regent's Park. At the last two of these stations the thermometers have long tubes with their scales some 6 inches or more above the surface of the ground and this construction does not permit of verification at the inspection of the station. At the other stations the thermometers used are those known as Symons's pattern, or a modification of the same.

TABLE III.—Lowest Readings of the Earth Thermometers during February 1895.

Station.	3 inches.		6 inches.		1 foot.		2 feet.	
	Min.	Date.	Min.	Date.	Min.	Date.	Min.	Date.
	°		°		°		°	
Rounton	...	...	...	...	32·0	20	...	...
North Thoresby	28·4	11	30·8	14	32·2	16	34·8	16
Somerleyton	...	...	...	...	33·0	20	...	...
Lowestoft	...	...	...	...	28·2	21	31·9	19
Bennington	...	...	...	...	32·0	17	...	...
Hodsock	...	...	...	...	32·2	17	...	...
Southwell	...	...	...	...	32·0	12	...	...
Aspley Guise	26·6	10	27·3	10	28·4	14	32·4	17
Berkhamsted	...	...	...	...	30·6	14	32·9	17
Regent's Park	...	...	...	...	28·2	14	34·0	19
Norwood	...	...	...	...	32·1	17	...	...
Wallington	...	...	...	...	30·4	18	...	...
Tunbridge Wells	...	...	...	...	31·9	17	...	...
Marlborough	...	...	28·0	12	31·0	17	...	...
Harestock	...	...	...	...	31·7	15	34·4	27
Stowell	...	...	...	...	31·0	15	...	...
Margate	...	...	31·7	15	32·6	17	...	...
Worthing	...	...	...	...	32·8	18	...	...
Portsmouth	...	...	...	...	32·0	...	...	...
Bolton	...	...	27·4	13	31·0	13	33·2	23
Rousdon	...	...	...	...	31·7	16	35·5	22
Tavistock	...	...	32·1	18	33·4	23	...	...

Frozen Water Mains.

The frost will long be remembered for its effect on the water pipes all over the country, in many cases householders being without water for more than nine weeks.

Mr. E. Pritchard, M.Inst.C.E., of Birmingham, who has been making inquiries on this subject at about 60 towns in various parts of the country, informs us that mains have been frozen which were laid so low as 3 ft. 3 ins.

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and 3 ft. 6 ins. respectively from the surface of the ground to the top of the pipe. The following are the depths at which mains have been frozen at several towns:—

	ft.	in.		ft.	in.
Alcester	2	6	London—G. J. W. ...	2	4
Braintree	2	6	Maidenhead	2	6
Burnley	2	6	Musselburgh	3	1
Bury	3	0	Nuneaton	2	6
Canterbury	2	6	Oxford	2	3
Cheltenham	3	0	Rhyl	2	2
Chester	2	3	Rotherham	2	6
Chesterfield	2	4	Sale	3	0
Coventry	2	6	Shrewsbury	2	6
Darlaston	2	3	Southport	3	0
Droitwitch	2	3	Stratford-on-Avon ...	2	6
Dudley	2	6	Swansea	2	2
Halifax	2	6	Tamworth	3	3
Handsworth	2	6	Twickenham	3	4
Hereford	3	6	Wakefield	2	2
Ipswich	3	0	Warwick	2	6
Kenilworth	2	3	Wednesbury	2	6
Kidderminster	2	4	West Bromwich ...	2	10
Leamington	2	3	Weston-super-Mare ...	2	3
Leicester	3	0	Worcester	2	9
London—E. L. W. ...	3	2	Workington	2	9

Mr. W. B. Bryan, M.Inst.C.E., the Engineer of the East London Water Company, informs us that "the frost has been very erratic, and that the nature of the soil appears to have had far more to do with the depth to which the frost penetrated than the intensity of the frost itself. In one case the main was frozen at 3 ft. 2 ins., and in many other cases of mains not more than 2 ft. in depth not a single case of freezing occurred."

Mr. J. Hall, Assoc.M.Inst.C.E., the Water Engineer of Cheltenham, writes that "the greatest depth to which the frost was found to have penetrated here varied from 2 ft. 9 ins. to 2 ft. 10 ins., but pipes have been burst at over 3 ft., and water mains full of ice have been found at nearly 4 ft. in depth, but there appears to be some reason to account for the action of the frost at greater depths than 2 ft. 9 ins. In all cases the main which has been burst or filled with ice at the extreme depths has, *within a short distance*, been less than 2 ft. from the surface, and I am of opinion that the ice has been formed in the following manner: The water flowing through the pipes has been at, or very closely below, 32°. When at this temperature it would be only just prevented from freezing by being in motion. When the private supply pipes were frozen there would cease to be any demand for water in the pipes. The water would then become stationary, and crystallisation would commence, resulting in the mains being filled with ice."

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In nearly all cases the mains which were frozen were under 6 ins. in diameter.

It must be borne in mind that but little snow fell during the period, and consequently the frost was able to penetrate into the ground without check.

Effects on Animal and Vegetable Life.

The intense cold caused great destruction in animal and vegetable life. Rabbits, hares, and game especially suffered, large numbers being frozen, and the remainder being in a great measure only kept alive by artificial food on the moors and fields, and in the farm yards. Deer left the forests in Scotland, and came in herds to the different farm yards, and to the numerous trains which were embedded in the snow, for warmth and food. The spectacle of the seagulls on the Thames will not soon be forgotten—how many were kept alive by food thrown on to the ice, and how many succumbed to cold and starvation.

In the vegetable kingdom there has also been great destruction. Wallflowers, calceolariæ, and roses have especially suffered, and in many places have been completely destroyed. A great many of the hardy shrubs, such as the Portugal laurel and euonymus, have perished, and even those which have not died have been greatly injured. The evergreen oaks, so common in the south of the United Kingdom, have lost their leaves, a circumstance which only occurs in the severest frost.

Comparison with previous Frosts.

With the view of comparing the late frost with those of previous years, we have compiled Table IV., which shows for London and its neighbourhood the number of times in each month of every winter from 1786 to 1895, the maximum temperature was 32° or below, 25° or below, and the lowest reading; and also the number of times the minimum temperature was 20° or below, 10° or below, and the lowest reading. The values given in this table have been extracted from—

1. (1786-1807) Bent's *Meteorological Journals*, Paternoster Row.
2. (1808-1813) Howard's *Climate of London*, Plaistow and Stratford.
3. (1814-1895) *Greenwich Observations.*

For the purposes of this paper we have considered the winter months to be November, December, January, February, and March.

On examining the table it will be seen that in no single month throughout the whole period have there been so many minima readings of 20° or below as in February 1895, the nearest approach being in February 1855 and in January 1881, when there were 10 such instances; but in each of these cases there were no minima of 10° or below, whilst in February 1895 there were two such readings.

On looking at the number of times the maximum was 32° or below, it will be seen that February 1895, when there were 11 such readings, has been exceeded several times, viz. January 1795, 21; January 1813, 15; January 1814, 25; February 1814, 14; January 1820, 13; January 1822,

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TABLE IV.—NUMBER OF DAYS, IN THE NEIGHBOURHOOD OF LONDON, WITH THE MAXIMUM TEMPERATURE 32° OR BELOW, 25° OR BELOW, AND THE LOWEST READING; ALSO THE MINIMUM TEMPERATURE 20° OR BELOW, 10° OR BELOW, AND THE LOWEST READING, IN EACH WINTER FROM 1786 TO 1895.

Winters.	Maximum.			Minimum.			Winters.	Maximum.			Minimum.		
	32° or below.	25° or below.	Lowest.	20° or below.	10° or below.	Lowest.		32° or below.	25° or below.	Lowest.	20° or below.	10° or below.	Lowest.
1786–7.			°			°	1810–1.			°			°
December	2	..	30·0	..	..	..	December	1	..	32·0	..	..	..
1788–9.							January...	11	..	27·0	6	..	14·0
November	1	..	31·5	..	..	..	1811–2.						
December	11	..	25·5	..	..	..	December	4	..	30·0	..	..	..
January..	11	..	26·0	..	..	..	1812–3.						
1791–2.							December	1	..	32·0	1	..	18·0
December	2	..	30·5	..	..	..	January..	15	1	23·0	1	..	20·0
January..	4	..	27·5	1	..	20·0	1813–4.						
February	1	..	27·5	1	..	17·5	December	4	..	30·0	1	..	19·0
1793–4.							January..	25	8	21·0	8	..	16·0
January	3	..	29·0	..	..	..	February	14	1	23·0	4	..	14·5
1794–5.							March ..	6	..	31·0	..	..	..
December	2	..	30·5	..	..	..	1814–5.						
January..	21	5	21·5	5	..	12·0	November	1	..	31·0	..	..	..
February	3	..	27·5	..	..	..	December	1	..	31·0	..	..	..
1795–6.							January..	9	..	26·0	2	..	15·0
November	1	.	31·0	..	..	..	1815–6.						
March ..	1	..	32·0	..	..	..	December	1	..	30·0	..	..	..
1796–7.							January	1	..	31·0	1	..	19·0
November	1	..	31·0	..	..	..	February	3	..	25·5	5	2	6·0
December	5	1	19·5	1	..	11·5	1816–7.						
January..	2	..	29·0	..	..	..	November	2	..	27·0	..	..	..
1798–9.							December	3	1	24·0	1	..	19·0
December	5	3	19·5	3	..	17·5	January..	2	..	29·0	..	..	..
January..	2	..	29·5	..	..	..	1817–8.						
February	6	..	28·0	..	..	..	December	8	..	29·0	..	..	..
1799–1800.							January	1	..	30·5	..	..	..
December	6	..	26·0	..	..	..	February	5	..	29·5	..	..	..
January..	1	..	27·5	..	..	..	1818–9.						
1801–2.							December	4	..	30·0	2	..	19·0
November	1	..	30·5	..	..	..	1819–20.						
December	2	..	32·0	..	..	..	December	6	..	29·0	1	..	13·5
January..	6	..	28·5	1	..	19·0	January	13	..	26·5	9	1	4·0
1802–3.							February	1	..	32·0	1	..	19·5
January..	9	1	25·0	..	..	..	1820–1.						
1803–4.							December	6	..	27·0	..	..	..
December	2	..	31·5	..	..	..	January	5	..	27·0	..	..	..
1804–5.							February	.	..	..	1	..	19·0
December	4	..	30·0	..	..	..	1822–3.						
January..	3	..	31·0	..	..	..	December	5	..	28·0	3	..	18·0
1805–6.							January	18	3	19·0	5	2	8·5
December	2	..	29·5	..	..	..	1824–5.						
1806–7.							February	1	..	32·0	..	..	..
January..	1	..	31·0	..	..	..	1825–6.						
February	1	..	31·0	..	..	..	January	8	..	26·0	7	1	9·0
1807–8.							1826–7.						
December	3	..	25·5	..	..	..	January	8	..	26·5	4	..	15·0
January..	2	..	27·0	2	..	12·0	February	5	..	28·5	4	..	15·0
February	3	..	29·0	2	..	17·0	1827–8.						
March ..	..	..	..	1	..	18·0	January	2	..	31·0	..	..	..
1808–9.							February	2	..	32·0	..	..	..
December	6	..	30·0	1	..	14·0	1828–9.						
January..	6	..	28·0	3	..	18·0	November	..	..	..	1	..	20·0
1809–10.	9						January	10	2	24·0	5	..	17·5
January..	1	..	28·0	5	1	10·0	February	1	..	32·0	2	..	17·0
February		..	32·0	2	..	11·0							

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TABLE IV.—NUMBER OF DAYS IN THE NEIGHBOURHOOD OF LONDON WITH THE MAXIMUM TEMPERATURE 32° OR BELOW, 25° OR BELOW, AND THE LOWEST READING; ALSO THE MINIMUM TEMPERATURE 20° OR BELOW, 10° OR BELOW, AND THE LOWEST READING, IN EACH WINTER FROM 1786 TO 1895 – *Continued.*

Winters.	Maximum.			Minimum.			Winters.	Maximum.			Minimum.		
	32° or below.	25° or below.	Lowest.	20° or below.	10° or below.	Lowest.		32° or below.	25° or below.	Lowest.	20° or below.	10° or below.	Lowest.
1829–30.			°			°	1853–4.			°			°
November	1	..	30·5	1	..	19·5	December	2	..	31·5	2	..	18·0
December	11	..	26·0	2	..	16·0	January	2	..	29·8	2	..	13·5
January	8	2	23·0	4	..	12·0	1854–5.						
February	6	4	19·0	7	..	13·0	January..	6	..	27·5	2	..	16·2
1830–1.							February	9	..	29·4	10	..	11·1
December	4	2	22·0	4	..	11·0	1855–6.						
January	1	..	31·0	2	..	20·0	December	4	2	23·2	2	..	16·9
1831–2.							1856–7.						
January	4	..	31·0	..	..	..	November	..	..	..	1	..	19·4
February	1	..	32·0	..	..	..	December	2	..	31·2	1	..	18·5
1832–3.							January..	..	..	..	1	..	20·0
January	2	..	31·0	1	..	20·0	February	1	..	31·6	1	..	20·0
1834–5.							1857–8.						
January	5	..	26·0	1	..	17·0	January..	2	..	29·0	..	..	..
1835–6.							1858–9.						
February	..	..	..	1	..	20·0	November	1	..	30·5	..	..	..
1836–7.							1859–60.						
December	4	..	30·8	..	..	..	December	6	..	28·0	4	..	14·0
March ..	..	..	..	1	..	19·5	1860–1.						
1837–8.							December	4	..	28·2	3	2	8·0
November	..	..	..	1	..	20·0	January..	5	..	29 7	5	..	16·0
January..	18	7	17·0	8	1	3·0	1861–2.						
1838–9.							November	1	..	31·5	..	..	..
January..	1	..	32·0	1	..	19·5	January..	4	..	28·4	..	..	..
March ..	..	..	..	2	..	19·3	1863–4.						
1839–40.							January..	3	..	28·1	2	..	14·3
January..	2	..	26·0	3	..	15·0	February	1	..	31·5	..	..	..
February	1	..	32·0	..	..	..	1864–5.						
1840–1.							December	1	..	30·5	2	..	17·3
December	9	..	26·0	6	..	16·2	January	1	..	29·4	3	..	19·0
January	3	2	16·7	4	2	4·0	February	3	..	28·5	1	..	15·5
February	8	..	25·1	3	..	12·4	1866–7.						
1841–2.							January	12	2	21·2	7	2	6·6
January..	3	..	28·0	..	..	..	1867–8.						
1842–3.							December	2	..	30·8	..	..	..
February	2	..	26·1	..	..	..	January	4	..	30·0	..	..	..
1843–4.							1868–9.						
January..	..	..	..	1	..	18·8	January..	1	..	32·0	..	..	..
February	2	..	30 9	1	..	20·0	1869–70.						
1844–5.							December	2	..	30·0	..	..	..
December	6	..	28·2	..	..	..	January..	..	..	..	1	..	19·6
February	3	..	29·3	2	1	7·7	February	6	..	27·7	1	..	19·4
March ..	4	1	24·8	2	..	13·1	1870–1.						
1846–7.							December	7	..	26·3	5	1	9·8
December	8	..	27·5	4	..	18·0	January	3	..	27·2	2	..	18·3
January	1	..	29·4	..	..	..	February	1	..	31·5	..	..	..
February	2	..	29·6	5		11·2	1871–2.						
March ..	..	..	..	1	..	16·9	December	1	..	28·7	1	..	18·6
1847–8.							1872–3.						
January	4	..	30·2	1	..	16·8	February	1	..	31·9	..	..	..
1848–9.							1873–4.						
January..	2	..	28·0	1	..	19·9	December	2	..	28·7	..	..	..
1849–50.							February	1	..	30·9	..	..	..
November	1	..	29·7	..	..	..	1874–5.						
December	..	..	..	1	..	18·8	December	5	1	24·5	4	..	18·5
January..	6	..	26·9	..	..	..	January..	..	..	..	1	..	18·2
March ..	..	..	..	1	..	20·0							

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Winters.	Maximum.			Minimum.			Winters.	Maximum.			Minimum.		
	32° or below.	25° or below.	Lowest.	20° or below.	10° or below.	Lowest.		32° or below.	25° or below.	Lowest.	20° or below.	10° or below.	Lowest.
			°			°				°			°
1875–6.							1888–9.						
December	2	..	31·0	..	..	..	January..	2	..	29·5	1	..	19·8
January..	1	..	27·6	2	..	17·4	February	..	..	..	2	..	18·9
February	1	..	28·9	..	..	..	March ..	..	..	..	1	..	18·7
1878–9.							1889–90.						
December	8	..	27·4	3	..	12·2	December	1	..	31·7	..	..	..
January..	8	..	26·1	1	..	19·4	March ..	..	..	..	1	..	13·1
February	1	..	30·4	..	..	..	1890–1.						
1879–80.							November	2	..	26·9	1	..	18·3
December	6	..	28·5	5	..	13·7	December	16	1	23·7	6	..	13·4
January..	4	..	27·1	5	..	17·2	January..	9	1	24·4	3	..	12·0
1880–1.							1891–2.						
January..	12	2	24·6	10	..	12·7	December	3	..	26·2	3	..	17·3
1882–3.							January..	2	..	31·4	..	..	..
December	2	..	29·1	..	..	..	February	..	..	..	1	..	18·8
1884–5.							1892–3.						
January...	1	..	31·9	..	..	..	December	2	..	28·8	1	..	17·6
1885–6.							January..	7	..	26·3	5	..	13·9
January..	1	..	29·0	1	..	16·5	1893–4.						
February	2	..	31·2	..	..	..	January..	5	2	19·0	5	..	12·8
1886–7.							1894–5.						
December	2	..	28·8	3	..	17·3	January..	6	..	28·7	..	..	..
January..	3	..	26·0	3	..	15·5	February	11	..	27·0	11	2	6·9
February	..	..	..	1	..	19·7							
1887–8.													
November	1	..	29·2	..	..	..							
December	1	..	32·0	..	..	..							
February	3	..	29·7	3	..	18·4							

18; January 1838, 18; January 1867, 12; January 1881, 12; and December 1890, 16.

The combination of such a large number of low maxima and minima temperatures makes the month of February 1895 unique, so far as London is concerned, since 1786. The long continuance of the frost, combined with its severity, points to the conclusion that during the last 110 years the winter of 1894-5 has only been exceeded by those of 1813-4 and 1794-5; and it is within the bounds of possibility, when we consider the imperfection of the thermometers of those early times, and the fact that registering instruments had been but recently invented, and were by no means common, that the winter of 1894-5 may even have exceeded in severity the two winters just mentioned.

In conclusion, we have to express our thanks to all those gentlemen who have kindly favoured us with information, and also to the members of the staff in the Society's office for assistance in working up the data.

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DISCUSSION.

Mr. H. SOUTHALL expressed his appreciation of the careful manner in which the facts had been marshalled by the authors of the paper. He gave various particulars concerning the thickness of the ice on the river Wye at Ross, during some of the severe winters from 1789 to the present year, and said that in the winter of 1814 snow fell to a very great depth, covering the hedges, and by alternate freezing and thawing the surface became so hard that people walked over hedges for miles. This cold period was known in Ross as the "twelve weeks' frost," but, as was the case in the recent frost, there was a break of one week of mild weather. The cold period in the winter of 1813-4 commenced on December 26th, and terminated on March 19th, a period of 84 days, whilst in the frost of 1894-5, out of 88 nights, ending March 19th, on 77 there was frost registered, the mean temperature of the whole period being only slightly in excess of that recorded in 1813-4. The effects of the recent frost on vegetation did not appear to have been so disastrous as in some preceding periods of severe cold.

Mr. C. L. PRINCE said that the temperatures recorded at his observatory at Crowborough, in Sussex, 774 feet above mean sea level, were the warmest in the county during the frost. The lowest minimum in the screen was 12°·8, and on the grass 5°·8, and at no other time did the thermometer in the screen fall below 14°. The mean temperature of February was 27°·4, and was the lowest in any month during the 52 years over which his register extended; December 1890, with a mean of 28°·4, being the next lowest, these two months being the only instances of a mean temperature below 30°. At Buxtead Park, 5 miles south from Crowborough, and 150 feet only above sea level, the lowest temperature registered during the recent frost was — 4°; and at Tunbridge Wells, which was 7 miles distant from Crowborough in a north-easterly direction, the thermometer in the screen registered 4°, while an exposed thermometer read — 1°, and one on the ground — 18°·2. From the morning of January 20th, 1838, a temperature below zero had not been recorded in Sussex (except on the temperature of radiation from grass or snow) until February 1895.

Mr. P. BICKNELL said that 44 days had been given as the number on which skating was allowed at Regent's Park, but in the grounds of the Toxopholite Society, where the London Skating Club met, skating was continuous for 50 days, and the ice was 11 inches thick. At Swavesey Fen, his son measured the ice and found it to be 2 feet thick.

Mr. C. L. PRINCE remarked that at East Grinstead the ice was 18½ inches thick, a loaded four-in-hand had been driven at a trot round and round Hedgecourt Lake to the extent of about a couple of miles, and not the slightest fracture was occasioned.

Mr. G. J. SYMONS said that the burst water-pipes appeared to be the effect of the lack of snow covering on the ground, as the quantity of snow which fell was insignificant and practically useless for the purpose of protecting the soil from the inroads of the frost. The water, too, that was distributed into the mains was almost at a temperature of 32°, and it was hardly to be wondered at that it speedily froze. It would be interesting if some physicist would state whether water under pressure froze at the same temperature as water not under pressure, and what influence motion had on the process of freezing.

Mr. M. JACKSON said that the minimum temperatures at Tonbridge, where he resided, occurred on February 7th and 8th, the readings being — 6°·0 and — 6°·5. It would be interesting to ascertain the cause of these periods of severe cold.

Mr. C. HARDING said that it was hardly correct to define the recent frost as extending from December 30th to March 5th, seeing that there was a week of mild weather in January, when the temperature was much above the average. It appeared to be desirable to arrive at some decision as to what should be considered as a frost. Concerning the question of the freezing of water in the pipes, it was well known that if water is kept perfectly still, its temperature can be as low as 14° or 15°; but when stirred it immediately becomes ice, and the temperature rises to 32°. It was stated in the paper that the recent frost was the only one in which the number of days in the month of February on which the minimum temperature was below 20° exceeded ten; but in a table printed in his paper on the frost of 1890-1 the period of January 10th to February 25th, 1855 was shown to have had 12 days with a minimum of 10° and less.

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Mr. W. H. DINES said that he had never before seen the common furze damaged by frost as it had been this year. With reference to the freezing of water under pressure, increased pressure lowered the freezing point, but to so slight an extent that it could in no way influence the bursting of water mains. He could not agree with the authors in ascribing the high death-rate of March to the frost. In the first place the death-rate was below the average for the first five weeks of the cold weather; secondly, it reached its maximum some time after the thaw commenced; and, the most important point of all, it occurred in conjunction with an influenza epidemic, and was due chiefly to the diseases which always accompany influenza, a similar mortality having occurred from the same cause in the extremely mild winter of 1889-90, and again in May 1891.

Mr. W. B. TRIPP inquired whether the cold strong wind which blew on the evening of Sunday, February 10th, would have been likely to produce any effect in reducing the ground temperature, as the water supply in the neighbourhood of Isleworth, where he resided, ceased after that date.

SOME HINTS ON PHOTOGRAPHING CLOUDS.

By BIRT ACRES, F.R.Met.Soc.

[Received March 28th.—Read April 17th, 1895.]

THE increasing interest that is being taken in the form, movement, and measurement of clouds, and the undoubted superiority of photography as a recorder of these phenomena, must be my excuse for describing my own experiences of cloud photography. I shall not discuss the formation of clouds, but only give a few hints as to the best manner of securing successful photographs of the different kinds, although I must confess to an inclination to expatiate on the beauty and grandeur of the subject.

One of the greatest charms of this much abused climate may be found in the fantastic forms, the subtleties of colour, and the delicacy of light and shade, that follow each other in rapid succession during unsettled weather, particularly in spring and early summer.

Fortunately, a study of the clouds does not involve expensive journeys, as the dweller in town has almost equal opportunities with his more fortunate confrère in the open country; even in the centre of smoky London the most magnificent skyscapes are often met with—the very presence of smoke, soot, and dust adding gorgeously ruddy tints which otherwise would be absent. To the observer in the heart of London, of course, the view is limited; but even in the most densely populated places there is ample room for observation and enjoyment; but to appreciate the beauties of cloud and sky to the full, it is necessary to reach some open space (such as the Thames Embankment or the bridges, for instance) in order that the forms and colours near the horizon may be seen.

It is true that photography cannot reproduce the glorious colours seen in nature, but with proper care and skill, and the choice of suitable apparatus,

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it may be made to render truthfully in monochrome the most delicate forms and brilliant effects of light and shade. The successful photographing of clouds is so entirely different from the ordinary run of photographic work, that very few photographers succeed in producing even passable results—except so far as sunset (sometimes called moonlight) effects are concerned, which are comparatively easy by reason of the enormous contrasts of light and shadow which obtain under such conditions. The principal difficulty lies in the difference between the visual intensity of colours and their action on a photographic plate. It is quite unnecessary for me to state that when a ray of white light is decomposed by a prism, a band of colours is produced, ranging from red (the least refrangible ray) through orange, yellow, green, blue, and violet, the latter being the most refrangible ray.

The most luminous colours are yellow and orange, but if we were to expose an ordinary commercial photographic plate to this band of colours we should find that these bright colours, yellow and orange, had produced no effect whatever on the plate, but that all the photographic action had taken place in the blue and violet bands, colours which to the eye appear quite dark, so that such a photograph would render blue and violet as nearly white, whilst all the other colours would appear of one uniform blackness.

If instead of an ordinary plate we use one that has been corrected for colour, that is, by the use of certain colouring matters made sensitive to the luminous rays, yellow, orange, &c., and expose it to the same spectrum band, we find that the yellow band comes out as light as blue, and green comes out much lighter than was the case with the ordinary plate. Now, by the use of suitable colour screens, we may cut off, or reduce in intensity, any desired part of the spectrum; and as in this case we wish to introduce the colours of the spectrum in their correct monochromatic value, we find it necessary to restrain the action of the blue and violet, and so must interpose a pure yellow screen. A green screen is not suitable for photographic work, except when it is desired to photograph greens and blues only, as the action of green is to absorb red and orange, and so lower their intensity. Pure yellow permits red, orange, yellow, and green to pass without loss; the blue and violet being alone cut off.

Let us apply these facts to the photographing of sky and clouds. We see delicate clouds faintly illuminated against a blue sky, but still to the eye the blue of the sky looks many tones darker than the cloud; yet, in consequence of the great photographic activity of blue, a photograph taken on an ordinary plate, in the usual way, fails to give the white cloud its proper luminous value. But if we employ a plate corrected for colour, and interpose a pale yellow screen between the sensitive plate and the sky, it will be found, on developing the plate, that the proper value of the cloud against the darker blue sky has been recorded.

There are many cases where a screen is not required, such, for instance, when it is desired to photograph brilliantly luminous cumuli against an intensely dark blue sky; then, by giving a suitable exposure, the values may often be correctly photographed even with an ordinary plate.

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APPARATUS.—I have found a magazine hand camera, holding a dozen plates of 4¼ in. × 3¼ in. size, most convenient for cloud work. I keep it always charged ready, so that if any special cloud formation presents itself, I am able to secure that without difficulty. Another advantage of the camera held in the hand, is that it can be rapidly pointed to different parts of the sky, or a series of exposures can be made at only a few seconds interval of the same mass of cloud, &c. I make a rule, however, to always work with a lens of one focus for each size camera; thus my lens for 4¼ in. × 3¼ in. size plate is 6 inches focus, and my lens for 12 in. × 10 in. camera is 18 inches. My object in doing this is so that I can always ascertain the angular measurements of clouds, whereas if I used lenses of various foci, it would necessitate marking the negative with the focus of the lens, and consequently comparisons between one negative and another would not be so easy as at present.

A lens of the rectilinear type will be found the most useful, stopped down according to the rapidity of the plate, the intensity of the light, and the depth of colour of screen (if any) employed. It is not possible to give even an approximate idea of correct exposure, as I have sometimes given an exposure of one-thousandth part of a second and secured good results, when only white streaks on blue had to be dealt with; and in other cases I have given several seconds to secure a delicate cirrus cloud, employing a Nicol prism.

PLATES.—I prefer for general cloud work plates that are known commercially as "Isochromatic," and the rapidity that I have found most useful is the "medium rapidity."

EXPOSURE AND DEVELOPMENT.—I have just said that it is not possible to give any idea of correct exposure, but I want to insist on the necessity of *full* exposure. I know that I am not in accord with most workers in recommending this; but experience has taught me that with a good moderately slow plate better results are obtained by fully exposing the plate and developing with judgment, than can possibly be obtained by aiming at a mathematically correct exposure.

I make it a rule always to back the plates, that is to coat the glass side with some substance that will absorb any light that may pass through the film, as unless this be done the light that passes through the film will be reflected by the under surface of the glass back to the film, and produce a blurred definition—technically known as "halation." The amount of blur being dependent on the strength and contrast of the lights and shadows, I usually employ for this purpose bitumen dissolved in benzene, which, in addition to being very effective in absorbing light, has the advantage of drying very rapidly, so that the plate can at once be placed in the dark slide. Further, the vapour of benzene does not produce any deleterious effect on the sensitive plate. *In no case* should any compound be used which contains turpentine, as the vapour of turpentine will cause the plate to become hopelessly fogged; and as this vapour has an affinity for wood, the dark slide will be rendered useless, unless it is carefully coated with an alcoholic solution of shellac, or is

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placed in the open air for a week or so. Bates's black, which may be obtained from any dealer in photographic material, is a convenient form of backing, and in cases where it is intended to expose the plate immediately, burnt sienna ground in water, which may be obtained at any oil shop, is most effective. This latter backing possesses the advantage of being easily removed with a wet sponge before developing the plate; but it will not produce any deleterious effect if it is left on the plate during development. To remove the bitumen or Bates's black, use a little benzene on a sponge. It is only necessary to remove enough of the backing to enable the opacity of the negative to be judged by transmitted light, the final cleaning of the plate may be left until after it has been washed and dried.

If it is desired to coat plates with burnt sienna for use at some future time, it is advisable to add a little gum arabic and glycerine to prevent the pigment drying up and powdering off, thus producing dust in the dark slide, which would cause myriads of pin holes in the finished negative. A preparation of caramel has been recommended for backing plates; but I have found bitumen or burnt sienna thoroughly satisfactory.

As it is of the utmost importance that none of the material used for backing should get on to the surface of the film, the easiest way is to lay the plate face downwards in the dark slide and then carefully paint the back with a camel's hair brush, if bitumen is used, or a moistened sponge or piece of clean rag if burnt sienna is used. When a plate is backed a much more prolonged exposure may be given than is permissible with an unbacked plate.

DEVELOPMENT.—Before commencing to develop a plate see that the dark room light is safe, that is to say, if you are using a plate sensitive to yellow and orange, the medium through which the light is filtered, be it glass or fabric, should be as nearly *pure* red as possible. Ruby glass cannot be relied upon for the purpose. I have examined large quantities of ruby glass with the spectroscope, and I have invariably found that it lets through a large quantity of yellow and green light, to say nothing of orange. The best medium that I have come across is the geranium red paper sold by dealers in photographic materials. If ordinary plates are used, two thicknesses of "canary medium" will answer well with artificial light—daylight is too uncertain to be used for the source of illumination of the dark room.

Proceeding to develop the plate, I first prepare in addition to the normal developer a second developer strongly restrained with bromide, the quantity of extra bromide depending largely on the class of negatives to be developed.

The normal developer I mix as follows:—

Pyrogallic Acid	2 grains
Liq. Ammonia ·889 ...	2 min.
Potassium Bromide ...	One or two drops of a 10 % solution
Water	1 oz.

To make the restrained developer, I double the quantities of pyrogallic acid and ammonia, and add from 15 to 80 drops of the 10 % solution of

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potassium bromide. In addition to this I keep handy a 10 % solution of potassium bromide in a dropping bottle.

I now proceed to flood the plate with the normal developer, and closely watch the result: if the image comes up steadily and correctly, I do not make any modification; but if it rushes up and the plate begins to blacken all over, I quickly pour this developer away and, without stopping to rinse the plate, pour on the restrained developer, and let it act until the image as seen by transmitted light has gained vigour. If the image then appears too strong in contrast, I rinse the plate well and allow it to remain in water for a short time, or apply a fresh solution of the normal developer without any bromide, according to the appearance of the plate. But usually allowing the plate to remain in clean water is the most effective method, as the film generally holds sufficient developer to enable the plate to gain more detail; and there is less risk of getting the image too opaque, as is often the case when fresh strong developer is used after a highly restrained one. When the image does not show up at its proper time after applying the normal developer, I usually dilute the developer with water according to circumstances, in some cases putting ten times as much water as developer. In this way I have sometimes been able to save a plate that seemed hopelessly under-exposed.

In developing negatives of brilliantly lighted cumulus clouds, the greatest care must be taken to prevent the image becoming too opaque, particularly if a colour sensitive plate and a yellow screen have been employed; otherwise in the resulting photograph the blue of the sky will appear quite black, whilst the delicate half tones in the higher lights will be lost. For such subjects it is better to dilute the normal developer with two or three times its bulk of water. Going to the opposite extreme, in developing a negative of the delicate cirrus clouds, it is often desirable to commence with the highly restrained developer previously mentioned, otherwise it is difficult to produce any contrast between the clouds and the sky, even when a colour sensitive plate and a yellow screen have been used.

Screens.—It is necessary to point out that ordinary pieces of glass are not suitable for colour screens—the glass must be optically worked with surfaces absolutely parallel to each other.

Nicol Prism.—So far I have only treated of photographing clouds by means of colour sensitive plates and suitable screens, but I have found these to fail sometimes when trying to photograph some of the almost invisible cirrus clouds; and as I had been impressed with the curious phenomena that are presented to the eye when the sky is examined through a Nicol prism, I have used such a prism with the lens. Briefly described, the effect which takes place is this: when the Nicol prism is pointed to the sky and revolved slowly round, it will be found that in some positions the blue sky light is much reduced in intensity—in fact appears to change colour; but any clouds that may be in the field of view are not affected in this way—the light from them is not quenched, hence they appear to stand out brilliantly white against the dark sky. More careful observation of the position in which the Nicol prism most effectively quenches the sky light will show that the

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maximum effect takes place when the prism is held so that its longer diagonal is at right angles to an imaginary line drawn from the sun to the part of the sky examined; that is, if the prism is pointed to a part of the sky at the same elevation as the sun, but to left or right of it, the maximum effect of cutting off sky light takes place when the longer diagonal is perpendicular. But if a part of the sky above or below the sun is examined, then the maximum effect is found when the longer diagonal of the prism is held horizontally; intermediate points between these would necessitate it being held in the same relative position to the sun. This phenomenon is most marked when a part of the sky at right angles to the sun is examined. Having noted this effect, I naturally turned it to account in photographing clouds, and was rewarded by obtaining some remarkable results. It is hardly necessary to state that the reason the Nicol prism cuts off the sky light in some positions is that the light is polarised. If ordinary unpolarised light be examined, no difference will be found in whatever position the Nicol prism is held. This accounts for the fact that the clouds stand out brilliantly when the sky light is cut off. The light from the cloud is not polarised, hence it passes freely through the prism in any direction.

I have omitted to mention that a useful piece of apparatus is a perfectly plain optically worked black glass mirror, set in front of the lens. This seems to perform two functions, partly acting as an analyser, cutting off the polarised light of the sky, and partly as an absorbent, the blue sky light seeming to be more absorbed than the white light from the clouds.

DISCUSSION.

Capt. D. WILSON-BARKER, in a note to the Secretary, said:—"Mr. Birt Acres' paper is an extremely interesting one from the pictorial and photographic side of the cloud question, although I must take exception to some of his remarks on the formation of clouds. No remarks can add to the use of the polarising appliance for cloud photography after the beautiful pictures he has shown on the screen to prove this point. I should, however, like to point out that I was using screens as early as 1887, placed at the back of the lens. The screens were formed by exceedingly thin films of mica, which can be obtained of almost any colour and transparency. Mine were specially prepared for me through the kindness of Mr. Wiggins, the well-known mica merchant, and the results obtained by using these screens on the upper clouds, using the ordinary plates, was a decided improvement on working without the screens. My custom is to use a small stop and instantaneous exposure, $\frac{1}{10}$ of a second or thereabouts, and develop slowly with an iron developer. In the case of the cirrus and other thin clouds, it is almost impossible to tell when the plate is exactly developed, and a certain amount of guessing, corrected of course by experience, is necessary when removing from the developer. Printing under green glass often improves the results. I quite agree that a hand camera is the best for obtaining cloud snap shots, as it can be used instantly and pointed anywhere to the sky without trouble."

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THE MOTION OF CLOUDS CONSIDERED WITH REFERENCE TO THEIR MODE OF FORMATION.

By W. N. SHAW, M.A., F.R.S.

A Lecture delivered before the Royal Meteorological Society, March 20th, 1895.

The invitation to take up the responsible position which I hold to-night has placed me in a situation of great embarrassment. The only reason which could in any way justify my accepting the invitation amounts to this, that the science of Meteorology may be regarded as the Physics of the Earth's atmosphere, and (from circumstances over which I have had very little control) one of my daily duties is to expound the elementary principles of Physics to a succession of members of the rising generation.

My embarrassment arises from two sources. First, that in undertaking to deal with the application of Physics to Meteorology, I am allowing myself to face the facts of nature in some of their most perplexing and difficult forms. Now as teachers of Physics we are accustomed to arrange subjects in such a way that we can manage them. We simplify the conditions until we can deal with the facts. We have an authority for doing so which is very high and very much respected. The greatest of ancient philosophers in giving directions for instructing the youth in Astronomy (a kindred study), writes in the seventh book of the *Republic*:—"And do you not think that the genuine astronomer will view with the same feelings the motion of the stars? That is to say, will he not regard the heaven itself, and the bodies which it contains, as framed by the heavenly architect with the utmost beauty of which such works are susceptible? But as to the proportion which the day bears to the night, both to the month, the month to the year, and the other stars to the sun and moon, and to one another,—will he not, think you, look down upon the man who believes such corporeal and visible objects to be changeless and exempt from all perturbations; and will he not hold it absurd to bestow extraordinary pains on the endeavour to apprehend their true condition? Hence we shall pursue astronomy with the help of problems, just as we pursue geometry; but we shall let the heavenly bodies alone, if it be our design to become really acquainted with astronomy, and by that means to convert the natural intelligence of the soul from a useless into a useful possession."

Such is Plato's idea of the proper method of teaching astronomy. We teach the principles of Meteorology after a method not dissimilar. Throughout history, for the purpose of teaching Physics, Nature has been, if not

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conventionalised, at least limited by careful selection of the facts. But the facts of your science laugh at the limitations which the physicist would like to impose, and I find myself suddenly confronted with your real atmosphere, with its moisture, its dust, its warming and its cooling, its electricity, and I know not what besides (far different from the ideal atmosphere of a laboratory or a lecture room). You will, I hope, be tolerant if the result is merely cloud or fog.

Secondly, I have in my daily routine the advantage of addressing an audience not less ignorant of the subject matter than myself. To-night the relations are reversed, and I have, unfortunately for myself and for you, to address, from the point of view of ignorance, an audience of experts. It is too late now to withdraw or alter, but may I take the liberty to suggest that if you should on any future occasion be kind enough to ask the co-operation of a mere pedagogue in Physics like myself, you should ask him not to give a lecture which must infallibly betray his own ignorance, but to set an examination paper in the subject. I feel certain that it would be easy to ask some questions which you would all regard as interesting, and while you wrote the answers, I should have no difficulty in sitting here to see that no one copied; if the answers were good enough to deserve full marks, they would do more for the development of your science than I could do in a lifetime of lecturing.

The department of your subject to which I wish to call your attention is the motion of clouds, and in particular the consideration of the question whether the motion of the cloud really indicates the motion of the air in which the cloud is formed. The question is an important one, for so much of our information about what is going on in the upper strata of the atmosphere depends upon observations of cloud and cloud motion. It arises, so far as I am concerned, from some *dilettante* attempts to deduce the motion of air masses from the shapes of clouds, and if possible to picture the conditions of motion. To illustrate my meaning, I will take the liberty of putting before you some specific instances in which the motion of air seems not properly indicated by the clouds. The most conspicuous and typical is the case of the mountain cloud-cap. There is, I suppose, nothing in nature which looks so absolutely peaceful and at rest as the cloud which surrounds a mountain top on a bright summer day. But in the cloud itself there is quite another state of things. No one who has experienced it need be reminded that the apparent rest is really compatible with a strong, cold, unpleasant wind carrying the fog with it, apparently, so long as you are close enough to see separate parts. The cloud-cap really defines a locality where cloud is formed in the wind as it travels past the top; a little beyond the top the cloud disappears.

I have sometimes noticed phenomena in the case of ordinary fog which I put into the same class. I will not inflict upon you a photograph of a fog, but merely mention a particular observation. In a thick fog, lasting a whole day of last winter, in Cambridge, I had occasion to pass and repass certain streets in the course of the day. There were certain localities all

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included within a half mile on the same level in which the fog was always conspicuously lighter than elsewhere. The motion of a fog is no doubt very slow, but I do not think it is entirely absent, and I regard those localities as positions in which the fog thinned from evaporation while the air passed over them. But I cannot explain why it should do so, any more than I can explain the limits set to the cloud-cap.

The third instance is a cloud that grew from a small cumulus into a thunder cloud. It has, I believe, frequently been observed that thunder clouds come up against the wind. I have heard the apparent motion attributed to an upper current of air. I regard it myself not as a moving of the cloud either against the wind or with an opposing upper current, but as the formation of fresh clouds in positions successively more and more to windward. On the screen is a photograph of a cloud that developed itself above a village in the Gulf of Genoa in a somewhat peculiar manner. It started as an ordinary cumulus above the hill at the back of the village, and grew out as a long horizontal strip of cloud. Here the cloud had a growing point like a plant, but did not move as a whole. It developed in a few hours into a thunder cloud, and ultimately disappeared with a thunderstorm.

The fourth example is shown in a group of cumulus clouds. It is well known that a cumulus cloud is the cap of a rising column of vapour-laden air, and the lower surface of the cumulus marks the height at which condensation begins. But the ascent of air in one part corresponds to its descent in other parts, and consequently the question one naturally asks one's self on seeing a cumulus is: "Where is the air coming down?" In most cases it is difficult to give an answer. Take for instance a sky full of small cumulus clouds. It would appear necessary that the spaces between the cumulus clouds should be occupied by descending air, and the air circulation that is in progress in such a sky must be a very complicated one; but the only motion apparent is the steady horizontal progression of the cumulus clouds across the sky, which gives but a faint impression of the real motion. I once watched such a sky form on a bright morning above the narrow neck of land that forms the St. Ives promontory in Cornwall; the cumulus clouds travelled with a North wind, and formed initially over the land alone. It was difficult not to attribute the initial formation to the sun's heat on the narrow strip of land, but the clouds persisted as they travelled out to seaward in the south, and eventually the sky became overcast. In this case vertical motion was clearly indicated by the shape and grouping of the clouds, whatever may have been the horizontal motion.

On the other hand, I have endeavoured on some occasions to measure the rate of travel of cloud shadows, hoping thereby to deduce the velocity of the upper strata of air. The most suitable occasion is generally when a North-west wind is driving the scud of a cyclone across bright sunshine. My measurements have been very rough, and have generally come out about 40 miles an hour. This seemed so reasonable and satisfactory, that it was difficult to think that one had not some definite air-motion indicated by the observed motion of the clouds. Of course vertical motion

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would not be specifically indicated, but it would probably be small compared with the rapid horizontal motion, and its neglect would not be serious.

We may get a little light thrown upon the subject by considering for a moment the artificial clouds formed by the discharge of steam and smoke from chimnies. An observer, unacquainted with the habits of locomotives, who measured the velocity of a distant but well-marked cloud of familiar shape, and supposed he had measured the velocity of air, would be clearly wrong; he would really have measured the velocity of the funnel of the locomotive. That may be actually what one measures in the case of cumulus. On the other hand, a smoke puff emitted from a stationary chimney moves with the wind (making a small allowance for the effect of gravity), and the same is true of steam if one is near enough to see the motion of the separate puffs of steam, but not otherwise. To sum up this part of my subject, we may say that, although a motion of cloud does indicate part, in some cases nearly the whole, of the truth as regards air motion, in others the visible cloud boundaries show merely the limits of position in which condensation is taking place or disappearing, and the change of these positions is not necessarily an indication of the motion of the air in which these clouds are formed.

Let us then proceed to examine the causes of the formation of cloud, and see whether they will throw such light upon the subject as will enable us to distinguish between the cases.

There are two recognised causes of formation of cloud.

I. The mixing of two currents of different temperatures.

II. The so-called dynamical cooling of air by diminishing the pressure.

It is assumed by many writers that clouds are formed by the mingling of currents moving in opposite or different directions at different altitudes. Now I will not, in the presence of so many meteorologists, deny the possibility of such a state of things, but I will merely ask in what direction you would expect a cloud so formed to move? Suppose, for example, the currents to be north and south respectively: will the cloud formed by mixing move north or south, or east or west? The cloud would surely be formed in the "no man's land" between the two prevailing currents, and its motion would be entirely misleading if regarded as an indication of the motion of either. We should not therefore expect to get indications of air motion from observations of clouds in such a case. The real fact is that conditions would have to be very peculiar for such an arrangement to take place. Probably most of the meteorological phenomena we observe take place in the stratum intermediate between the streams of prevailing air currents. In such a case as that indicated above there would be what might be called discontinuity in the motion of the air at successive levels; and though a cloud might fairly be supposed to move for some distance with its air, it is difficult to say what inference could be drawn from any particular observation.

Another example of the formation of cloud when there is discontinuity of motion is given by ground fogs. They arise, I suppose, in two cases;—

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I. When cold air passes over a warm moist region, either a pond or moist ground; and these are strictly analogous to the steam formation over a pan of hot water. The fog is then localised by the representative of the pan, and belongs to the cloud-cap class of clouds. Fragments of cloud may move with the air, but such fragments often disappear rapidly, and the whole cloud viewed from a distance would appear stationary.

II. When warm moist air passes over a cold surface.

This case is illustrated by the fog, which I understand is apt to surround icebergs. Here again the cloud is localised by the iceberg or its equivalent, and is apparently stationary. It belongs again to the cloud-cap class.

I can, however, imagine a case in which mixing might take place when the motion of cloud would indicate the motion of air, provided I may assume that the vertical motion is a very important element in defining the direction of air currents, in the regions between the centres of the rising and falling streams; and I should like to show you how very easily vertical motion is produced in air. The smallest difference of temperature is sufficient to cause a change of density which gives rise to vertical motion. [This was shown by means of a paper spiral suspended by a silk fibre.] Let us consider what would happen to the air over an area strongly heated by the sun's rays; we should have a sort of chimney with air coming in all round the base. Such an arrangement may be the one which in reality occurs when a cyclone is formed, the air supplying the currents at the base will be drawn from warm moist regions in the south or west, and from cold dry regions in the north or east. Where they meet they will not probably ascend vertically, as in the case of an ordinary chimney, but be wrapped up together in spiral streams. Where cold and warm currents are side by side, cloud will be formed by the mingling of the streams of air. At the boundary of this region, where the cold air is beginning to predominate there may be detached clouds travelling with the spiral motion and fairly indicating the motion of the air; such motion will be nearly horizontal if the area of the cyclone is large. It is perhaps carrying speculation too far to suggest that the scud which comes with the North-west wind at the tail of a cyclone marks the limiting position of the mixing of the warm Southerly current with the cold Northerly one; but I believe that the explanation of the phenomenon may be found in that direction. It does not seem impossible to work out a consistent and satisfactory theory of the origin and motion of cyclones by regarding them as moveable chimnies of vast width and height, but not necessarily in every case having their bases at the ground level. There is not time this evening to dwell longer upon the subject. I will, however, show an experiment on the formation of cloud by the mixing of air currents, and ask you whether you think you can detect the motion of the air by watching the movement of the cloud.

A glass globe (Fig. 1) provides the arena in which the currents mix. The currents are due to the heat of a spirit lamp or gas jet, burning at the base of a chimney which communicates with the top of the globe. On either side of the globe are tubular openings through which air can flow to feed the

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chimney. The air supply on the one side is warmed and moistened, on the other it is cooled by a freezing mixture. The apparatus can be so arranged that no cloud is formed with either one of the currents acting singly, but when both act together a conspicuous cloud is formed extending up to the

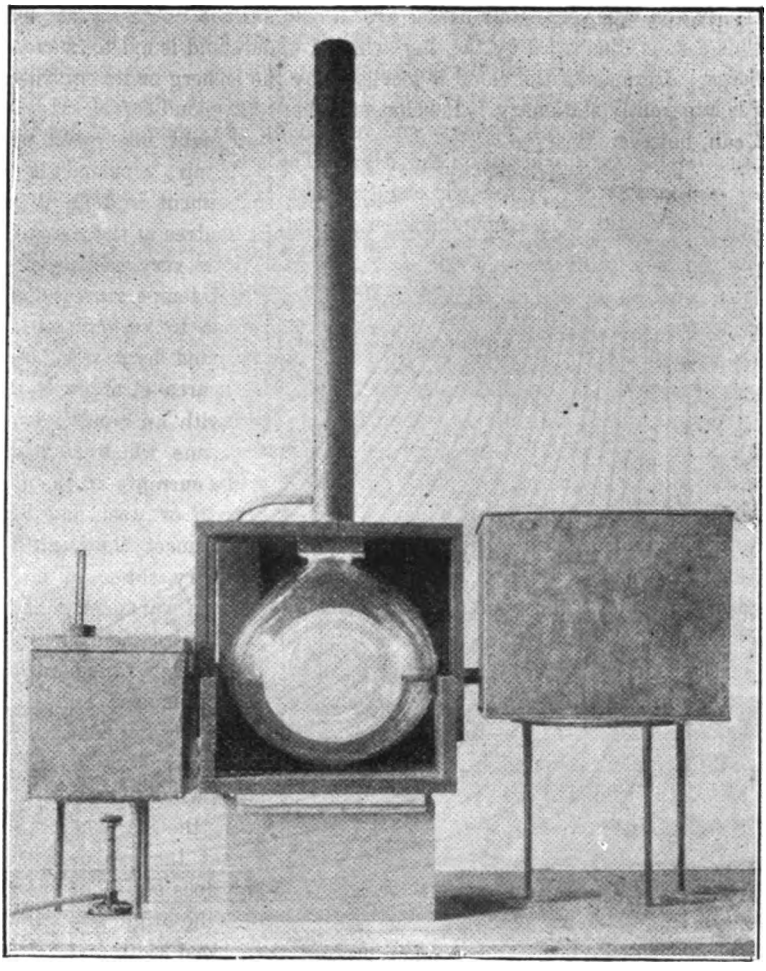

Fig. 1.

chimney, and showing by the motion of its parts the direction in which the air is moving. The spiral motion, which is clearly visible, is attributable to the fact that the tubes which deliver the air are more or less parallel, but not diametrically opposed to one another.

Let us now consider the second cause of cloud formation. The cloud in this case arises from so-called dynamical cooling of the air. To produce

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the cooling all that is required is to allow the air to expand and overcome the external pressure while protecting it from all communication of heat. The arrangement is sufficiently nearly realised when air rises into regions of diminished pressure in consequence of its density being less than that of the surrounding air. The small density may have been originally due to rise of temperature. The amount of the cooling effect in dry air produced under such circumstances is very well known, and, indeed, is quite easily calculated on the assumption that the laws of perfect gases are accurately followed.

The way in which the effect can be for many purposes most satisfactorily represented is by a diagram (Fig. 2). The black lines in the diagram represent the relation between pressure and volume for one gramme of dry air at various temperatures marked on the edge. The red lines (shown as dotted lines in the figure) represent the changes that take place in pressure and volume when there is no communication of heat.

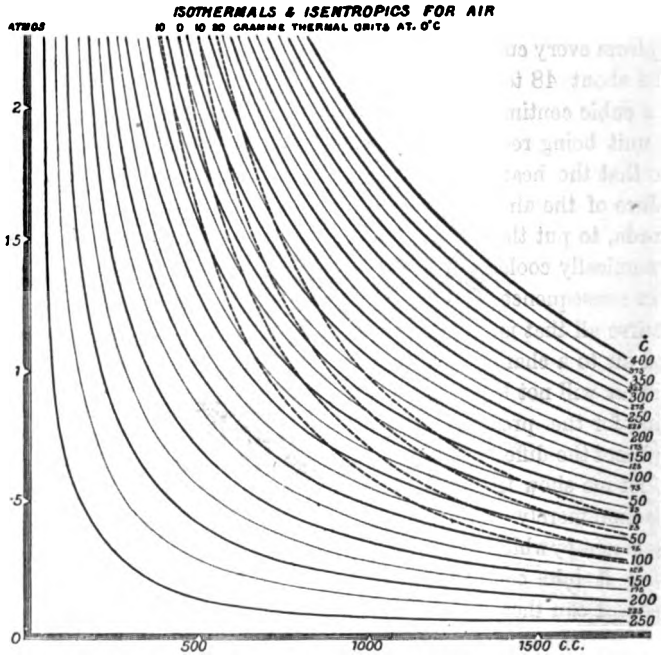

FIG. 2.

To pass from one black line to the next on the right, 10 gramme thermal units of heat must be communicated to the gramme of air at the freezing point; and here I must parenthetically remark that it would be well for those who wish to lay hold of this part of the subject to get rid of the very natural notion that change of temperature is a necessary concomitant of supply or removal of heat. Doubtless in many cases the two are connected, but progress in thermo-dynamics is facilitated by recognising that the tem-

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perature may change without any supply of heat, and heat may be supplied without any change of temperature. A small addition to the diagram makes it available for showing the change of temperature which results from the raising of dry air to a specified height from sea level.

But the atmosphere does not consist of dry air; it contains a variable amount of moisture. So long as the air is unsaturated, its behaviour under diminution or increase of pressure does not differ materially from that of dry air, and the diagram we have already considered may be used to indicate the changes of temperature. But when the cooling is so great that the dew point is reached, a serious modification is introduced. The condensation liberates the latent heat of vapour, which is numerically very great, so that although the amount of water condensed may be very minute, the disturbance of the thermal conditions is by no means unimportant. An example will make this clear. The cooling of saturated air from 15° C. (59° F.) to the freezing point would correspond to the deposition of 8 grammes of moisture from every cubic metre, or 8 millionths of a gramme (a very small amount) from every cubic centimetre. The heat liberated by the condensation would be about 48 ten-thousandths of a thermal unit; but the capacity for heat of a cubic centimetre of dry air is very small, only 2½ thousandths of a thermal unit being required to raise the temperature of that quantity of air 1° C., so that the heat liberated by the condensation is sufficient to raise the temperature of the air from which it is condensed through about 20° C. In other words, to put the result in a somewhat Hibernian form, if saturated air were dynamically cooled from 15° C. to 0° C., its temperature would rise to 20° C., in consequence of the condensation of vapour.

Of course all that is meant by this absurd statement is that if you subject saturated air to a change of pressure which would cool dry air through 15° C., the moist air will not be cooled to anything like the same extent.

Leaving for the present the theory of the subject, I shall try to show you by experiment the difference of behaviour of air under the conditions specified.

First, let me show the formation of a cloud by dynamical cooling—that is, by rarefaction merely—in moderately dry air. I have here (see Fig. 4, p. 180) an arrangement by which the pressure of air in a globe can be rapidly diminished by putting it into communication with a vessel which has been partially exhausted. I can thereby ascertain what would happen to the air if it should be suddenly raised through 5,000, 10,000 or 15,000 ft. You will, I think, see that a cloud can be formed in that way.

Let me now go on to exhibit, if possible, the difference between the temperature change produced in dry and moist air. A slight addition to the apparatus enables us to form a rough estimate of the depression of temperature below that of the room at the instant when the expansion is complete. At that instant I close the communication between the exhausting vessel and h experimental globe with its cooled air. At the same time I put the globe in communication with a pressure gauge, and watch the change of pressure which occurs as the air in the globe recovers the temperature of the room.

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We will try the experiment with dry air. You will notice that after the serious disturbance of the gauge, as the expansion proceeds, there ensues a gradual increase of pressure which indicates the change of temperature. This is the well-known experiment of Clément and Desormes. By making experiments successively with a globe of dry air and a globe of saturated air, the rise of temperature could be roughly compared in the two cases; but in order to avoid part, at least, of the initial disturbance, I propose to exhaust the two globes simultaneously (Fig. 8), and have one limb of the gauge in connection with each globe. With the apparatus so arranged, the ultimate difference of level of the liquid in the two limbs of the gauge will indicate the difference of temperature which existed in the two globes at the instant when the expansion was complete. With a water gauge a difference of level of one inch corresponds to a difference of temperature of $1\frac{1}{2}$° F.

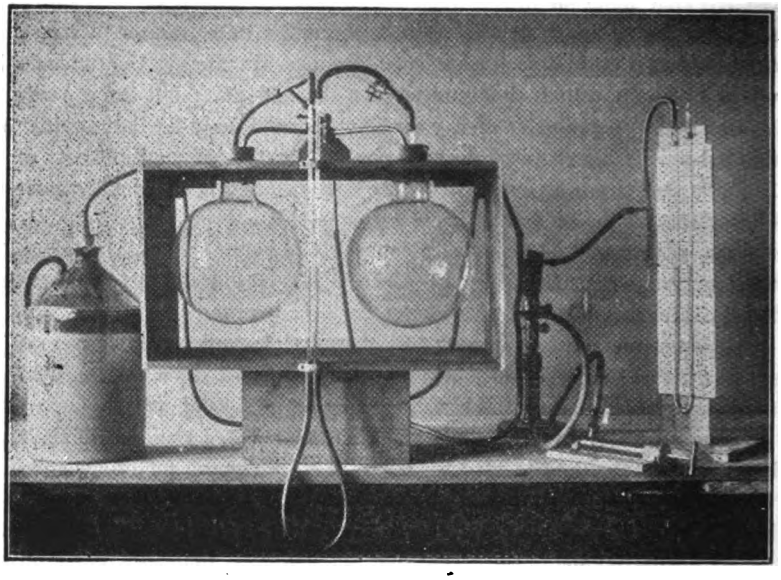

Fig. 3.

In this experiment the expansion is small, and the temperature difference may be scarcely perceptible. I shall be content if it is shown by any difference of level in the gauge. I ought to remark that the saturation of the air introduces a slight modification of the figures, and gives moist air an advantage on the gauge which ought to be eliminated before the method could be recommended as an accurate one for scientific purposes.

The effect of condensation in modifying the dynamical cooling of moist air depends very materially upon the position of the dew point of the air, because with a high dew point the amount of moisture condensed, per degree of depression of temperature, is much larger than the corresponding amount

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condensed when the dew point is low; for example, the amount of condensation from saturated air corresponding to a depression of 5° C. from 30° C. is 7·1 grammes per cubic metre; but from 5° C. to 0° C. it is only 2·1 grammes per cubic metre.

The behaviour of moist air could be represented by a set of lines corresponding to those which I have shown you for dry air, but the lines would be of different shape. A diagram which represents the behaviour of moist air was constructed by the late Dr. Hertz, so well known in connexion with electrical waves. It is somewhat too complicated for this evening. It may suffice to give the results of some rough calculations in connexion with this part of the subject. I have computed that a change of pressure sufficient to cause a dynamical change of temperature in dry air of 27° F. would not depress the temperature of saturated air at 41° F. through more than 18° F., nor saturated air at 86° F. through more than 6° F.

I hope to find time later on to call your attention to the meteorological effects which these modifications of dynamical cooling probably produce; but in order to follow the main thread of my argument with respect to clouds I must pass on to consider the suspension of solid and liquid particles in the air.

I will again form a cloud, and I wish you to notice closely what happens in the globe. As soon as the cloud is formed, the drops begin to fall. Some of them, doubtless, become invisible in consequence of the evaporation of the moisture; but if the disappearance were entirely due to the communication of heat through the glass of the globe, the last traces of cloud would appear at the centre or in the upper part of the globe. That, however, is not the case; there is clearly a falling of the particles going on. We may therefore conclude that when a cloud is formed in still air, the particles of which the cloud consists fall through the air at an appreciable rate. The rate is different in the two globes before you, because probably the size of the water particles is different. The smaller globe has been supplied in great abundance with nuclei upon which drops can form, while in the larger one nuclei are comparatively rare, and consequently to carry the deposit each nucleus must be more heavily loaded.

If there were a suitable upward motion of the air, the particles forming the cloud might appear stationary—there would still be relative motion between the water particles and the air. No refinement of subdivision can free the particles from the ubiquitous and inevitable action of gravity; and so long as the particles have a specific gravity greater than that of air, they can only be maintained at a fixed level by the action of forces due to the air passing by them. [Speaking in the technical language of dynamics, the particles can only be maintained at a fixed level by supplying to them an amount of momentum equal to that which gravity constantly supplies, but in the opposite direction. The momentum is withdrawn from the stock which the rising column of air possesses, and a condition for the transference of the necessary momentum is relative vertical motion between the cloud particles and the supporting air. In every case, therefore, when a cloud is supported there is a vertical rush of air past the particles of it which keeps them up.]

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The amount of relative motion which is necessary to support the particles depends upon their weights and areas, and therefore, of course, upon their size, and the uprush of air must increase rapidly if the particles are continually growing in size.

From another aspect these ideas may be expressed by considering a raindrop or hailstone supposed to form in still air. It will begin to move downwards however small it may be, but its downward velocity will never exceed a definite limiting value depending upon its size and weight. What the limiting velocity of falling raindrops may be I do not know, but from the rate at which the drops of a thunder shower fall we may fairly conclude that a very considerable, though by no means inconceivable, upward current of air would be required to keep the drops of a thunder shower suspended at a fixed level. Clearly a smaller current would suffice to keep up winter rain or Scotch mist, and ordinary ground fog is so finely distributed that the vertical motion necessary to support it is hardly, if at all, perceptible.

All that has been said on this point must be understood to refer to vertical motion only. So far as horizontal motion is concerned, when a cloud of particles has once accommodated itself to the motion of the air carrying it, there will be no relative motion unless the air changes its speed, so that the horizontal motion of air may be indicated by the horizontal motion of cloud while the vertical motion is not.

Let us now consider the case of a mass of warm, moderately moist air starting from the earth's surface and gradually rising. With increasing height the pressure and density will diminish; the temperature will fall, rapidly at first, as the diagram indicates, until it reaches the dew point. Then a cloud will be formed, and the rate of fall of temperature will be much diminished. The condensed particles will gradually sink, and at the same time the upper strata will receive heat from the sun's rays which are there absorbed. The upper layers will be ready to go on rising, and as they are saturated with moisture cloud will be formed at higher and higher levels, and thus, unless the initial difference of density was very great, we may have equilibrium very nearly approached, and the mass may move very slowly upward, carrying with it the greater part of a very light and almost permanent cloud. In the mean time the heavier globules of the moisture deposited in the earlier stages will have fallen downward, and may be evaporated lower down, or fall as rain. Perhaps the air may even be regarded as like a rocket, moving upward and leaving a trail of cloud globules behind it, and may, after becoming transparent again for a time, ultimately show itself in some form of cirrus cloud.

I must, however, here recall to your memories the now well-known fact that for a cloud to be formed two conditions must be satisfied—there must be not only a supply of vapour to be condensed, but also a supply of nuclei (formed of particles of dust, &c.), upon which the drops of rain may be deposited. This part of the subject almost belongs to Mr. John Aitken, who has founded upon the principles of it a method of counting the dust particles in the air. Now although it is not possible by lifting the air to ex-

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haust the whole supply of vapour, the supply of nuclei may be exhausted, and then, unless the air carries with it globules already condensed, deposition will no longer take place, and the air will pass upward free from cloud, but "supersaturated" with moisture. I use the term because it has been used before, but the necessity for the existence of nuclei, in order that deposits may be formed, points to a vagueness in the meaning of the word 'saturated' that requires clearing up. Nuclei may not all be of the same character, and the condensation may take place at first upon nuclei of one sort only. When they have been loaded and have dropped out, further rarefaction may cause another set of nuclei to come into use. It would be interesting to know what depression of temperature is necessary to cause condensation upon nuclei of different characters, and what relation the temperatures at which condensation takes place bear to the ordinary dew point. These questions carry me, however, beyond my own knowledge and experience: I must limit myself to showing, later on, some experiments in connexion with the formation of coloured coronæ that I think indicate a change in the character of the deposit with a change in the number or character of the nuclei.[1]

Let me, however, now take up the consideration of the meteorological effects of the liberation of latent heat when condensation takes place. I propose to take only the two extreme cases, (1), when the air is very cold; (2), when it is very warm. The cooling in the first case is considerable even when condensation takes place, because the actual amount of moisture condensed for a given fall of temperature is, comparatively speaking, small. The rising air will therefore sooner reach a position of equilibrium. A cloud may be formed, but no further rise need result; the deposit is thin, and the rain, if any, is fine. In the second case the deposit of moisture for a given range of temperature is many times larger. The fall of temperature incidental to expansion is very much less. Hence, as the warm air rises it remains warm in consequence of the condensation of a part of its vapour, and becomes surrounded by air, higher, and therefore, presumably, colder than that which surrounded it originally. Having risen to a certain height, its tendency to rise becomes still greater; it is further away from a condition of equilibrium than it was when it started. The higher it rises, the greater will be the force tending to make it rise. The result will be an uprush of air which may be described as almost explosive in its character.

To this difference we may attribute the suddenness and violence of the thunder showers of summer as compared with the fineness of the rain of winter. Explosive uprushes, such as those here referred to, have long been recognised as furnishing an explanation of the formation of hail. If we were acquainted with the electrical effect of air rushing past globules of water—a state of things that must occur if the globules are to be supported—we might

[1] Mr. C. T. R. Wilson, at a meeting of the Cam. Phil. Soc., in May 1895, showed experiments tending to prove that whatever is the state of the air as regards nuclei, the rarefaction cannot be carried beyond a certain definite limit without cloud being formed. The limit is not beyond that of practical meteorological altitudes.

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reach a tolerable explanation of most of the characteristic phenomena of thunderstorms.

I shall now, by way of summary, sketch what seems to me the probable state of motion of the air in which cumulus cloud is forming, and in some of the other instances quoted above.

As already intimated, cumulus cloud is indicative of an upward motion of air. Its base shows the position at which condensation commences, the upward motion being sufficient to retain the globules suspended, and possibly carry some of them further upward. A spreading of the base of the cloud indicates only that the area of the "chimney" is altering or its position changing. It does not necessarily imply any specific horizontal motion of the air. In the example of the large cumulus over the Gulf of Genoa: if we suppose warm, moist air to be gradually drifting in from sea towards the hills, successive portions more and more to seaward would bulge upwards, and there would be a spreading seaward of the conditions favourable to cloud formation, in a direction, that is to say, opposite to that of the wind.

It is not easy to picture the conditions which define the upper surface of a cumulus cloud. It is, I think, most probable that the cumulus should be regarded as the same in nature as a cloud-cap, the air running more or less vertically through it. After the first formation of cloud on the rising air, further elevation would cause an increase in the size of the drops; but as the size increased the power of the air to carry them with it would diminish. Ultimately it would have to leave its droplets behind, and pass on clear but saturated with moisture. The process would free it of the nuclei upon which the drops formed, and this suggests a definite limit to the cloud surface. The sun's rays would necessarily introduce some modification, and make the surface lower and the cloud consequently of less thickness. It must, I think, be accepted that the sun cannot alter the temperature of the air which holds the cloud. Heat is only taken in from the sun's rays in any appreciable quantity so long as there are water globules; they will be surrounded by saturated air. The heat absorbed under these conditions evaporates the moisture without alteration of temperature. As soon as the moisture is all evaporated, the air has become transparent, and the rays pass on to give out heat elsewhere. The evaporation caused by the sun will, however, enable the air to carry with it some of its nuclei.

It therefore would appear that the air issuing from the top or sides of the cloud leaves behind it its larger globules of moisture, and therefore nearly all the nuclei in which moisture was first deposited. If condensation again occurs, and a fresh cloud is formed in the same air, it must be under different conditions, *i.e.* with a different set of nuclei.

When the sky is full of patches of detached cumulus, the vertical circulation is less simple. A layer of warm air of considerable horizontal area must come, on its upward way, into a state of instability when condensation begins to take place. The condensation in any small portion puts that portion in a more favourable condition for further ascent than the surrounding portions in consequence of the liberation of latent heat. Some

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allowance must be made for the alteration of density consequent upon the contraction of volume which takes place when condensation occurs; but this allowance is not large, and, moreover, when the air finds the drops of water heavy to carry, it leaves them behind. As soon, therefore, as condensation takes place at any point, there is an upward rush there, associated with a sinking of air around; hence the clouds form themselves permanently round the spots where condensation begins, extending or disappearing according to circumstances, which can at present only be regarded as accidental. The elaborate vertical circulation here sketched may be associated with a general horizontal motion of the air due to some dominant cause external to the whole district.

In a subject like that here treated, general conclusions are particularly hazardous; but there seems to be some ground for concluding that when clouds are formed by mixture their motion may be accepted as indicating that of the air in which they are formed, but that when they are formed by the dynamical cooling due to rarefaction, no satisfactory indication of the motion of the air is given by the motion of the clouds.

In the course of my remarks I have referred to possible effects of an alteration in the number or character of the nuclei upon which the globules of moisture are formed. It now only remains for me to illustrate experimentally the effects alluded to. If the globe (Fig. 4) in which a cloud is formed by a sufficient rarefaction is illuminated by means of a brilliant point of light, coloured rings are shown surrounding the bright point, provided that the air is in a suitable state. The condition for the formation of coronæ, as explained by Young, is that the globules formed should be sufficiently uniform in size to produce regular diffraction, and Young has also pointed out that the diameter of a ring of particular colour depends upon the size of the particles, becoming smaller if the globules of which the cloud is formed become larger. Experimentally, the diffraction rings are easily watched if the globe be surrounded by a blackened screen perforated by a hole, and an electric lamp be brought close up to the hole, and a cloud be then formed in the globe. The necessary rarefaction can easily be produced by opening free communication between the globe and an exhausted receiver of suitable size. If the globe be fully supplied with nuclei in one of the ways suggested by Aitken, as by allowing the smoke of a match to pass into it, the rarefaction produces cloud without definite colouring, probably because the nuclei are so numerous and irregular that no regular diffraction takes place. After a number of rarefactions and consequent precipitations, a circular distribution of colour begins to show itself round the bright spot. The colours change as the cloud grows in density, and after many deposits have been made, a series of alternate red and green rings (with artificial light) of measurable radius becomes perfectly distinct, while the globules become large enough to be separately visible, and can be seen settling down in the globe. The size of the rings under these circumstances becomes

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moderately permanent for successive rarefactions, and would enable the observer to compute the size of the particles if there were a standard of reference available with particles of known size. I have not yet, however, succeeded in imitating the effects with other particles, nor can I say what

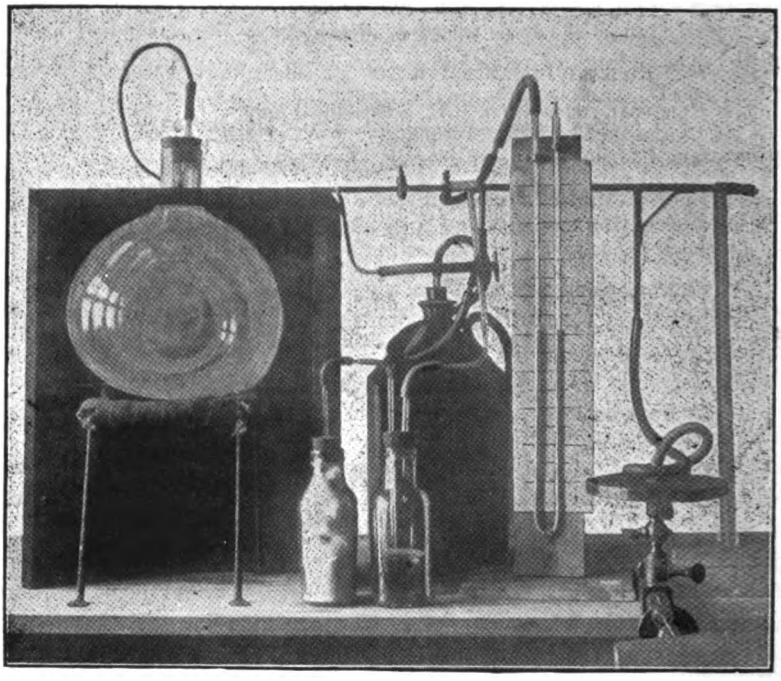

FIG. 4

the change in the character of the nuclei must be, nor what rarefaction with air of given humidity is necessary to give rings of a particular diameter. These matters are, however, within the reach of an experimenter in this subject.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

March 20th, 1895.

Ordinary Meeting.

C. THEODORE WILLIAMS, M.A., M.D., Vice-President, in the Chair.

HECTOR HATCH GAMMELL, Perry Barr, Birmingham;
CHRISTOPHER LLOYD, 1 Invicta Villas, Balmoral Road, New Brompton; and Lt.-Col. WILLIAM WOODWARD RAWES, R.A., Junior United Service Club, S.W., were balloted for and duly elected Fellows of the Society.

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Mr. W. N. Shaw, M.A., F.R.S., gave a Lecture on "The Motion of Clouds considered with reference to their Mode of Formation," which was illustrated by experiments. (p. 166.)

April 17th, 1895.

Ordinary Meeting.

Richard Inwards, F.R.A.S., President, in the Chair.

Capt. Percival Ashworth, R.E., Shorncliffe Camp;
John Chapman, The Lawn, Torquay;
Edwin J. Pearson, J.P., Millfield, Berkhamsted;
Stanley Single, Woodcote, Dorking;
Capt. Edward Richard Taylor, Ardgillan, Balbriggan, Ireland; and
C. Algernon Whitmore, M.P., 75 Cadogan Place, S.W.,
were balloted for and duly elected Fellows of the Society.

The following communications were read:—

"The Frost of January and February, 1895, over the British Isles." By Francis Campbell Bayard, LL.M., F.R.Met.Soc., and William Marriott, F.R.Met.Soc. (p. 141.)

"Some Hints on Photographing Clouds." By Birt Acres, F.R.Met.Soc (p. 160.)

CORRESPONDENCE AND NOTES.

Notes on Clouds.—I began registering clouds in 1842, and have kept this up to the present time, and have many thousand records, which I intend to reduce if I have health. My relative (Luke Howard) first persuaded me to pay attention to clouds; and I think I was the first to adopt the term "scud," which I did in 1843. At that time I invented signs for clouds; and almost immediately afterwards a code of signs were sent to me that, though independent, were almost identical. I had the following columns for each observation:—Height (0—6); Velocity (0—6); Thickness (0—6); Colour (0—6); Direction (0—6); Class At the same time was recorded "prospect." I think you use the word "visibility." When at Highfield House, Beeston, near Nottingham, I recorded the following:—1. Charnwood Forest, 27 miles off, and according to clearness registered 0—6; 2. Beeston Railway Station, 2 miles; 3. The Lake, Highfield House, ½ mile; 4. The sunk fence of the garden, 100 yards; and 5. A yew tree, 40 yards.

Since I came here I have selected as my objects Dunkerry Beacon, Stee Holmes, Cheddar, Clevedon, Denny Island, Caldicot, Caractea's tree, far end the park 500 yards, and this end of the park 50 yards off. I must remark t' mists here are never as much as 20 yards, whilst at Highfield House they v so great that the prospect was sometimes only 2 yards.

I have never seen it recorded that cirri do not move along their lines; grow at their ends. I have also never seen it mentioned that there are ments *inter se* different to the currents they are moving in. Nor have I recorded that in thunderstorms there will be scud boiling from beneat often in the opposite direction to their movement.

Here we can see clouds at great distances, as our uninterrupted west through south to east is 172 miles. We are also often above and can look along their edge. I reported a case where a cirrus fo a stratus, and both at a lower level than this house. On anoth recorded cirri forming directly above the stratus that lay ove Channel when the sky was elsewhere cloudless, and this occurre

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8th and 9th, 1895. The water must have been very cold, as the Wye at Chepstow was frozen, though tidal. The stratus and cirri were only over the water, as the Somerset hills were quite clear.

Sometimes we see marvellous clouds. On one occasion since I have been here we had a dense fog all day, with overcast sky, but for a few minutes there was an oblong opening in the mist, through which we could see the steep Holme and Dunkerry Beacon, nearly 40 miles off. The fog must have been confined to this hill.—E. J. LOWE, F.R.S., Shirenewton Hall, Chepstow, March 13th, 1895.

The Upper Atmosphere.—On July 7th, 1894, Dr. Assmann set free at Charlottenburg a balloon, equipped with self-registering apparatus for the determination of meteorological data in the higher regions of the atmosphere. This balloon, the *Cirrus*, made a most remarkable voyage, for not only did it reach the greatest altitude ever attained by any contrivance made by human hands, but it also in eleven hours made a journey from Berlin to the district of Zvornik in Bosnia, a distance of more than 620 miles. The scheme of exploring the upper air by means of small balloons was first proposed by Geheimrat A. Meydenbaur, and put into practice in France; but these attempts failed because no measures were taken to guard against the powerful effects of solar radiation on the instruments. This was rendered possible by the aspiration principle applied by Dr. Assmann, and, after many trials, a camera largely composed of aluminium was constructed by R. Fuess, in which an alcohol thermometer and the lever of a barograph could be photographed through a slit on to a silver-bromide gelatine paper stretched on a drum. On the morning of the 7th the *Cirrus* was released, shot up "like a champagne cork," sailed first towards the north-west, and at a greater height turned round towards the south-east, finally coming to earth in Bosnia, close to the Servian frontier. The meteorologist Berson, who went to fetch the balloon, was only able with all possible haste to reach the spot in fifty-four hours, while the balloon had made the journey in twelve hours. The apparatus was hardly injured at all; and the photogram, unrolled ten days later, showed clearly the pressure and temperature of the regions traversed by the balloon. When the balloon rose the pressure was 30 ins., and the temperature of the air 62°·6. Both naturally diminished with the height, the pressure to 3·35 ins. and the temperature to —61°·6. Here the record breaks off, for the paper was not large enough, such low pressures not having been expected. According to a careful calculation, the height then attained must have been 53,559 feet, or not much less than twice that of Mount Everest, the highest mountain of the world. Evidently the balloon had ascended still higher, but its highest point could not be recorded. Besides, the registering apparatus was arranged for six hours only. It is to be altered so as to record lower pressures and to act for twelve hours.

Studies of the Upper Air.—Mr A. L. Rotch recently read a paper before the Boston Scientific Society, U.S., on this subject, in which he described the methods employed for obtaining a knowledge of the movements, etc., of the upper air, and mentioned some of the results which had been attained. Man has seldom penetrated into the stratum above 4 miles, and of course the rarefaction of the air, whose pressure at a height of 10 miles is less than one-ninth of the pressure at sea-level, is the chief obstacle to its exploration by beings like ourselves. Twice during the past 88 years men have reached a height of about 30,000 feet in balloons; they have climbed in the Himalayas to an altitude of nearly 23,000 feet, and, in each case, have observed the temperature and pressure during the few minutes they remained at these altitudes. Quite recently, instruments to record automatically these and other elements have been placed on the summit of a quiescent volcano in Peru, above 19,000 feet, from which it is hoped to obtain fairly continuous records. Latterly, also, other attempts in France and Germany have been made to gain information as to the temperature of still higher strata by liberating small balloons carrying no aeronauts but only self-recording barometers and thermometers. After giving an account of the various high level mountain observatories, and also of the observations of clouds, etc., Mr. Rotch concludes by saying "that observations on mountains are still the only ones capable of being made of all the elements at all times, although clouds can be observed very often, and their systematic study will even-

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tually be recognised as necessary for weather forecasting. Occasionally, observations in captive balloons and with kites will furnish reliable data in special cases when it is desired to investigate the conditions prevailing in the free air near the earth, but the necessarily infrequent observations which can be made at high altitudes in balloons carrying aeronauts, or the few automatic records obtained from unmanned balloons, which may reach still greater altitudes, will hardly do more than elucidate the general conditions reigning towards the top of the great aerial ocean."

Height of the Sea Breeze at Toulon.—Two interesting voyages were made in a balloon at Toulon on October 16th and 18th, 1893. On the 16th, MM. Louis Godard and Jacques Courty ascended from Toulon at 11.20 a.m., and were carried by a South-south-west wind towards Fort Faron. But at a height of about 1,600 feet the balloon began to turn towards the south, and at a height of 3,450 feet its course was due south. After passing the coast at an elevation of 4,690 feet it was carried by a North-easterly wind over the roadstead and the peninsula of Cepet. The aëronauts then descended, and found a South-westerly wind at an altitude of 1,000 feet.

On the second occasion an ascent was made at 4.20 p.m., and an Easterly current was found up to a height of 1,300 feet. At 2,000 feet the balloon was suddenly driven southwards towards the sea, and on descending to 520 feet entered the Easterly current again, and was carried to the Château of La Valerane on the Golfe de Giens.

From these experiences it appears that the land and sea breezes on the coast attain only a moderate height, at most 3,000 feet, and there give place to the general currents of the atmosphere. The limit is subject to constant changes, which must be controlled by the transition from day to night. The influence of the seasons on these breezes has still to be investigated. The change in the direction of the wind occurred at a much lower altitude, 300 to 400 feet, during the balloon experiments at New York in 1887. On October 16th and 18th Toulon lay at the south-eastern edge of an area of maximum pressure, with a fairly uniform pressure and light Easterly winds in the neighbourhood.

Dorset Annual Rainfall.—Mr. H. S. Eaton, a past President of the Royal Meteorological Society, has recently discussed the annual rainfall of the county of Dorset for the 45 years 1848-92, and communicated the results in the form of a paper to the Dorset Natural History and Antiquarian Field Club. Two maps accompany the paper: in one the general distribution of the rainfall is shown by blue shading, and in the other the brown shading is in proportion to the elevation of the land above sea level. From these maps it is seen that the distribution of the rain is in conformity with well known natural laws.

Mr. Eaton says :—"The vapour-laden air from over the warm water of the Atlantic, the chief source of supply, in passing inland from the coast under the prevailing South-west wind, is cooled by expansion in its onward progress over the hills, and discharges rain copiously, especially on their further flanks. A close observer of nature, but not a meteorologist, used to say of the rain on the high ground behind Abbotsbury: 'With a South-west wind the clouds get a blow from the hills, and cry on the other side.' Further on, over the low-lying lands of Somerset, the rainfall is 2 or 3 inches less than on the south coast of Dorset. Omitting the exceptional returns from Portland, Wimborne, and Tudbeer, it will be noticed that between Lyme Regis and Bridport the rainfall is slightly under 34 inches, falling to 30·5 inches round Weymouth, and to 30 inches round Poole. Inland from the coast it rises from 33·4 inches at Bridport to 34·0 inches at Netherbury, which is 125 feet above sea-level and 5¼ miles from the coast, to 39·3 inches at Beaminster, 1¼ miles further on at the foot of the hills; and to 42·6 inches at Cheddington, just on the watershed dividing the English from the Bristol Channel, 604 feet above the sea. Thence it declines to 33·3 inches at West Coker, 240 feet above the sea, and to 28·4 inches at Ilchester, only 40 feet above sea-level. Farther east, Abbotsbury and Littlebredy, a ridge of hills about 600 feet high intervening, the rain rises from 30·7 inches to 39·2, being 8·5 inches in less than 3 miles; and between Portisham and Littlebredy, in a distance of 2 miles, it increases 7 inches. Of the two stations of Upwey, that nearest the sea has an annual rainfall of 30·96 inches at

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70 feet above sea-level; the other 90 feet above the sea, and ¼ mile nearer Ridgeway Hill, has a rainfall of 33·05 inches. On the chalk hills extending from west to east across Central Dorset, the annual rainfall exceeds 40 inches. Here the county attains generally its highest elevation, from 600 to 800 feet. The highest point in the county, Pilsdon Pen, west of Beaminster, exceeds 900 feet, closely followed by Bulbarrow, near Haselbury Bryan. The hills are nearly as high east and south-east of Shaftesbury; but the clouds in their passage over Central Dorset lost a portion of their burden, and the rainfall in North-east Dorset does not quite attain 40 inches. North of Central Dorset the rain diminishes to 34 inches in Blackmore Vale. In the 5½ miles between Minterne Magna and Folke the diminution is 9·2 inches. Between Haselbury Bryan and Sturminster Newton the rate is still greater, being 15·5 inches in 4½ miles. At Haselbury Bryan, however, the fall of 49·0 inches may perhaps be increased by insplashing from some flints built round the gauge to support it in position; but the village is only 2½ miles north-west from Bulbarrow, which has an elevation of 903 feet, and 4 miles north-east of Church Hill, 822 feet, and Nettlecombe Tout, 854 feet, and it is the proximity of high ground rather than the actual elevation above sea-level that influences the fall of rain."

Old Rain Records from the Holy Land.—Among the shorter notices in the *Meteorologische Zeitschrift* for April is one by Dr. Hann on extracts from Vogelstein's paper "Agriculture in Palestine at the time of the Misnah," his Doctor's dissertation at Breslau in 1894. This deals with the Agriculture in Palestine during the first two centuries A.D. The Misnah mentions two seasons; the Rains and the Dry Season. The "Former Rain," to use the Biblical phrase, sets in soon after the autumn equinox. Its importance was such that if it was deficient, prayers were at once ordered, and continued drought was marked by a period of public humiliation. The rain was measured with a vessel. In the first rain 3·5 ins. ought to fall. In the second double as much, and in the third treble as much. In the second period the rain should fall for seven days without a break. The "former rain" is at the seed time; the "latter rain" in the month Nisan (March-April) is of the greatest importance for the harvest. Severe thunderstorms with hail occur during the rains. In the dry season rain is very unusual, but dew is very abundant and of the greatest benefit to the crops. The result is that the rain of Palestine in the first century amounted to about 21 inches per annum, a figure which agrees pretty well with modern measurements at Jerusalem.

Meteorological Charts of the Red Sea.—The Meteorological Council have recently issued an Atlas of Monthly Wind and Current Charts of the Red Sea, which have been constructed from observations mainly taken in the ordinary track of vessels passing along the central line of the sea, and the charts consequently only show the average phenomena in that line. A new form of wind-rose has been adopted in the preparation of the Wind Charts, which shows not only the frequency of the winds, but also their forces, so that an estimate may be formed of the direction and strength of wind likely to be experienced in any part of the sea.

From October to January the prevailing winds are Northerly over the northern half of the sea, but they are Southerly over the southern part, extending further north in these months than at any other time of the year. From February to May the Northerly winds extend further south, Southerly winds prevailing from Perim to about the 16th parallel; while from June to September Northerly winds blow over nearly the whole sea. Gales, which are most frequent during the winter months from November to March, are encountered chiefly in the southern part of the sea, and generally blow from the Southward.

The Current Charts give the set in each 24 hours, and an examination of the arrows shows that the currents in the Red Sea are somewhat erratic, and that while their velocity is not usually great over large areas, occasionally strong streams, frequently across the line of a ship's track, may be locally experienced. In the Straits of Bab-el-Mandeb direct observations are very deficient, but experience has shown that when the wind is strong from either the Northward or the Southward the current is generally strong in the same direction in these

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narrow waters. The currents often set with considerable velocity in the Gulf of Aden.

A feature of some interest has been noticed in the range of sea temperature in the Strait of Bab-el-Mandeb, near the Island of Perim. In this neighbourhood it amounts to 26° at the period of the South-west Monsoon; in September the highest temperature recorded being 92°, and the lowest 66°. A similar difference has been observed in July and August. In June and October the difference in the extreme temperature is 16°, and the least difference, 7°, occurs in February.

Currents of the North Atlantic.—The *Pilot Chart* for June has a map representing the drift in the North Atlantic, as indicated by bottle papers returned to the Hydrographic Office during the last six months, a star marking the spot at which the bottle was thrown overboard, a circle the point at which it was recovered, the line joining them being drawn in a majority of cases as nearly straight as intervening bodies of land would permit, and in the remainder, conforming to some extent with the well-established result of current observations. This chart, taken in conjunction with that of July 1891, published as a supplement to the *Pilot Chart*, indicates a circular movement of the waters of the Atlantic around a point lying to the south-west of the Azores, and coinciding with the anticyclonic region, around which the prevailing winds blow in a similar direction. Starting from a point to the southward of the Grand Banks of Newfoundland, the outer edge of this vast circulating system of waters mounts towards the north-east as far as the 51st parallel of latitude, there becoming easterly. North-west of the Azores, a portion of the current again takes a north-easterly direction, which ultimately lands these bottles upon the coasts of Scotland and Norway. The main body of the drift, crossing the meridian of 20° between 40° and 50° N. latitude, turns to the southward and parallels the shores of Europe and Africa until the latitude of the Canaries is reached, experiencing on its way south a slight deviation towards the Straits of Gibraltar. Quiting then the African coast, the external edge takes a south-westerly direction, unites with the northern portion of the equatorial current, and entering the Gulf of Mexico through the Yucatan passage, emerges as the Gulf Stream by the Straits of Florida.

Although the period of drift for the various bottles covers widely differing intervals and seasons, the results for any one region show a fair degree of accordance.

RECENT PUBLICATIONS.

American Meteorological Journal. January-May 1895. 8vo.

The principal articles are :—Variations in the character of the seasons: by H. Gawthorp (7 pp.).—The cause of the cyclones of the Temperate latitudes: by W. H. Dines (6 pp.). The author discusses the problem of the formation and maintenance of the cyclones of these latitudes, and after examining the theories of Ferrel and Hann, believes that the weight of evidence is decidedly in favour of the former's or the convection theory.—Recent foreign studies of Thunderstorms, V. and VI.: by R. de C. Ward (10 pp.). In these papers the author describes the work done in connection with thunderstorms in Russia and Switzerland during the last few years.—The study of atmospheric currents by the aid of large telescopes, and the effect of such currents on the quality of the seeing: by A. E. Douglass (18 pp.).—The study of atmospheric electricity at sea: by Prof. W. F. Magie (3 pp.).—Periods in Temperature: by Prof. H. A. Hazen (3 pp.).—The cause of cyclones: by Dr. A. Woeikof (3 pp.). This is a criticism of Mr. Dines's paper mentioned above.—Meteorological problems for physical laboratories: by Prof. C. Abbe (4 pp.).—Long range weather forecasts: by Prof. H. A. Hazen (4 pp.).—Topographic influence on the winds of the Weather Maps: by F. B. White (5 pp.).

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Ciel et Terre. Revue Populaire d'Astronomie, de Météorologie, et de Physique du Globe. January-June 1895. 8vo.

The principal meteorological articles are :—Fleurs de glace : par W. Prinz (20 pp.). This is illustrated by sketches and photographs showing the formation of rime or hoar frost.—Les grands froids observés en Belgique : par P. Marchal (9 pp.). The lowest temperature recorded in Belgium during the frost of 1894-5 was — 26°·7 at Ville de Bois. In Brussels the lowest temperature recorded in any winter was — 6°·0 in 1775-6.—La période de froid du 27 janvier au 17 février 1895 : par A. Lancaster (8 pp.).

Indian Meteorological Memoirs, being Occasional Discussions and Compilations of Meteorological Data relating to India and the neighbouring Countries. Vols. V.-VI. 4to. 1894.

These contain the following papers :—The diurnal variation of atmospheric conditions in India ; being a discussion of the hourly observations recorded at twenty-five stations since 1878. The stations dealt with in parts 4-6 of Vol. V. are Agra, Allahabad, and Lucknow.—The relation between sun-spots and weather as shown by meteorological observations taken on board ships in the Bay of Bengal during the years 1856 to 1879 : by W. L. Dallas. The author says that considering that the observations investigated extend over a period embracing only two cycles of the required number of years, and that the number of observations available for the different years varies so largely, the curves appear to afford confirmatory evidence that, side by side with other variations, there exists in certain classes of terrestrial phenomena an eleven-year cycle agreeing to a certain extent with the eleven-year cycle in the solar spots. As opposed to this, there is the fact that, so far as these observations show, there is no connection between the actual number of spots and terrestrial weather.—Investigation into the mean temperature, humidity, and vapour tension conditions of the Arabian Sea and Persian Gulf : by W. L. Dallas.

Instructions to Observers of the India Meteorological Department. By J. Eliot, M.A., F.R.Met.Soc., Meteorological Reporter to the Government of India. 8vo. 103 pp. 1894.

This book is intended to supersede the *Indian Meteorologists' Vade Mecum*, which is out of print. Meteorological observers in India now merely take the readings of certain instruments and forward the observations by telegram or by post to the Meteorological Office. The reduction and preparation of the data for subsequent use and discussion is done in one or other of the Meteorological Offices in India. Hence this book of "Instructions" is confined to a description of the various instruments in use at the meteorological stations in India, the precautions to be taken to maintain them in good order, the methods to be used to restore them to good order when it is possible for the observer to do it, and the proper methods of reading the instruments and of taking and recording the observations.

Kongliga Svenska Vetenskaps Akademiens Handlingar. Band 20. Afd. I. No. 8. 8vo. 1895.

Contains :—Sur la distribution à Vienne et à Thorshavn des éléments météorologiques autour des minima et des maxima barométriques : par P. Akerblom (36 pp.). This is a continuation of an investigation of a similar character published in 1883 by Prof. Hildebrandsson, as regards Upsala only. Dr. Akerblom has chosen Vienna as a continental and Thorshavn as an oceanic station, and has investigated the distribution of each element as regards the position of the observing station with respect to maxima and minima. The paper does not allow of being abstracted for these pages, but it is of interest to find that in several particulars Dr. Akerblom's results confirm those given by the Rev. W. Clement Ley in his paper on "The Relation between the Upper and Under Currents of the Atmosphere around areas of Barometric Depression," which appeared in the *Quarterly Journal Roy. Met. Soc.* Vol. III. (1877), p. 437. One very interesting result comes out from the paper. The observations of M. Richter at Ebersdorf in Silesia have shown that the motion of cirrus in that district are very different from those found to exist both in Sweden and England.

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Dr. Akerblom has tested the Silesian results by others from other places in North Germany, and he says that he can arrive at no other conclusion than that in Sweden and England the axes of cyclonic disturbances reach up into the region of cirrus cloud, while in lower latitudes the disturbances have less vertical depth.

Meteorologische Zeitschrift. Redigirt von Dr. J. HANN und Dr. G. HELLMANN. December 1894-April 1895. 4to.

The principal articles are: Zum 250 jährigen Jubiläum des Barometers: von G. Hellman (6 pp.). This is a *résumé* of the correspondence in Italian which passed between Torricelli and others in the years 1643-44.—Natur und Ursache des Polarlichtes: von A. Paulsen (12 pp.). This is a paper translated from the *Verhandlungen der Konigl. dänischen Akademie der Wissenschaften in Kopenhagen.* Dr. Paulsen, during his stay in Greenland in 1882-3, had copious opportunities of observing aurora. He found that the steady displays did not affect the magnetic needle, while those that moved rapidly did affect it. The curtain displays had the greatest action. The author goes on to show that it is not the electricity which produces the aurora, but that the former is a secondary phenomenon due to the latter. He considers the auroral light to be a phenomenon of fluoresence, produced by the absorption of an energy developing itself by radiation and having its origin in the upper region of the atmosphere. In other words, it is not the arch or the curtain which emits the light, but invisible rays which become luminous by change in the energy.—Der Regenfall auf den Hawaii Inseln: von J. Hann (18 pp.). This is an interesting account of the climate of the Sandwich Islands, based on the observations collected by Mr. C. J. Lyons, Director of the Weather Bureau in Honolulu. Dr. Hann discusses wind and rain. He shows how the Trade wind blows constantly at low levels, and becomes a wet wind as it is forced to ascend, and a dry wind after it passes the cols. If the mountain range is too high for the Trade to get over it, regular land and sea breezes set in on the lee side. The paper contains several rain tables, and gives us more complete information than exists for any other group of islands in the Pacific.—Ueber das Wetterleuchten: von Dr. W. Meinardus (8 pp.). This is an attempt to explain the inaudibility of thunder in the case of sheet lightning by the total reflection of sound waves from air strata of different density superposed on each other. The author cites as a proof of his theory that thunder has been heard in balloon ascents at much greater distances than ever occurs at the surface of the earth. The explanation is the same as that of mirage for waves of light.—Zur Kenntniss des täglichen Ganges der Luftfeuchtigkeit in den Thälern der Centralalpen: von Dr. F. V. Kerner (9 pp.). This is a discussion of observations carried on with Kappe's hair hygrometer for four summers at Trins, in the Gschitz Thal, in the district of the Brenner. The investigation is carried out in great detail as regards the variations in vapour tension and relative humidity with different winds, such as Föhn winds and South-easterly wind.—Temperatur und Feuchtigkeitsbeobachtungen über und auf der Schneedecke des Brockengipfels: von Dr. R. Süring (8 pp.). These observations were carried on through the winter of 1893-4, and give a fuller amount of material of the action of a snow covering than existed elsewhere. The following are the final results:—1. In making such observations no protection from wind can be used, as the differences materially depend on wind force. 2. The difference of temperature between the air and snow surface increases with temperature and with clearness of sky. The differences at the height of 1 cm. are reduced to one half their value. 3. With cloud or snow, the snow surface is usually warmer than the air. This arises from the quicker cooling of the air. 4. The vapour tension and relative humidity of the air is usually greatest immediately above the snow. 5. The conditions for the evaporation of snow are much more favourable than for condensation. The setting in of the latter is generally shown by the occurrence of hoar frost.—Wolken-studien von Clement Ley: von H. Hildebrandsson (9 pp.). This is a review of the first portion of *Cloudland*, and it merits careful study from Dr. Hildebrandsson's eminence as one of the highest authorities on and most diligent students of clouds. He points out that Mr. Ley's altitudes differ considerably from those of other observers, and also that the idea of basing a classification of clouds on the differences of origin of the different types is premature, as the agencies which give rise to clouds have not sufficiently been studied. Dr. Hildebrandsson compares Mr. Ley's classification

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of clouds with that adopted by the Committee at Upsala.—Ueber Gewitterbildung und labiles Gleichgewicht der Atmosphäre: von Prof. W. von Bezold (4 pp.). This paper on the formation of thunderstorms, and on the unstable equilibrium of the atmosphere, was originally prepared for and sent to the Chicago Congress, but as it has not yet been published in English, Prof. von Bezold brings it out in German. He first reminds his readers of the distinction Mohn has drawn between heat thunderstorms and cyclonic thunderstorms. The latter are characterised by occurring independently of diurnal period, being as common by night as by day, in contrast to heat thunderstorms, and by being more frequent on the coast than inland. A necessary condition for the production of a thunderstorm is the existence of a strong ascending current. Such a current must carry water up to a level at which it shall be congealed to hailstones. The very heavy drops of thunder rain can only be explained by their being hailstones thawed in their fall. This action also explains the chill which comes on in thunderstorms. All heat thunderstorms are due to unstable equilibrium in the atmosphere, and this is attributable to three separate actions, viz.—1, overheating of the lowest strata; 2, overcooling of the upper strata, an agency first pointed out by Prof. W. M. Davis; and 3, retardation in the change of condition from ice to water. The author points out that the third agency is very likely to come out at sea, as there the formation of oversaturated air is most easily explained. The paper concludes with an appeal for continuous observations from ships taken from self-recording aneroids, in order to see if the phenomenon of the sudden increase of pressure in thunderstorms is noticeable at sea as on land.—Eine einfache Formel, die ungefähre Höhe der Wolkenbildung bei adiabatischen Zuständen zu bestimmen: von R. Hennig (6 pp.).

Rainfall in the East Indian Archipelago 1893. 8vo. 1894. 416 pp.

The number of stations for which the daily rainfall is given is 194, of which 104 are in Java and Madoera, and 90 in Sumatra, and the various islands of the Eastern Archipelago. The station reporting the greatest rainfall in 1893 was Pelantoengan, Java, 109°59′ E. long. 7°6′ S. lat., the total amount being 204·72 ins. The greatest monthly fall was 45·05 ins. in February, of which amount 12·05 ins. fell on the 5th.

Results of Rain, River, and Evaporation Observations made in New South Wales during 1893. By H. C. Russell, B.A., C.M.G., F.R.S., Government Astronomer for New South Wales. 8vo. 1894. 226 pp. and 4 plates.

In 1870 there were only 5 stations in the colony reporting rainfall; now Mr. Russell has an organisation of 1,286 stations. The rainfall for 1893 was 28 inches, which was very satisfactory. This, with the years 1889, 1890, 1891, and 1892, makes up a series of years during which the seasons were exceptionally good; indeed, there have been no similar series of equally good years. The highest floods on the Darling River at Bourke were 34 ft. 8 ins. on March 26th, and 39 ft. 3½ ins. on July 15th.

Symons's Monthly Meteorological Magazine. January-May 1895. 8vo.

The principal articles are:—The Gale of Saturday, December 22nd, 1894 (2 pp.).—The Thunderstorm of January 23rd, 1895 (5 pp.).—Classification and Definition of Clouds: by A. L. Rotch (2 pp.).—The Frost of January and February 1895 (5 pp.).—Earth Temperatures and Water Pipes (11 pp.).—The Great Gale in the Midlands on March 24th (3 pp.).

The Scientific Roll and Magazine of Systematized Notes. Conducted by Alexander Ramsay. 8vo.

The author has started another volume of *The Scientific Roll*, which is devoted to "Climate: Baric Condition." An abstract is given of various books, &c., dealing with the barometer and atmospheric pressure, and also bibliography of works on the subject. Parts 1 to 7 have been published.

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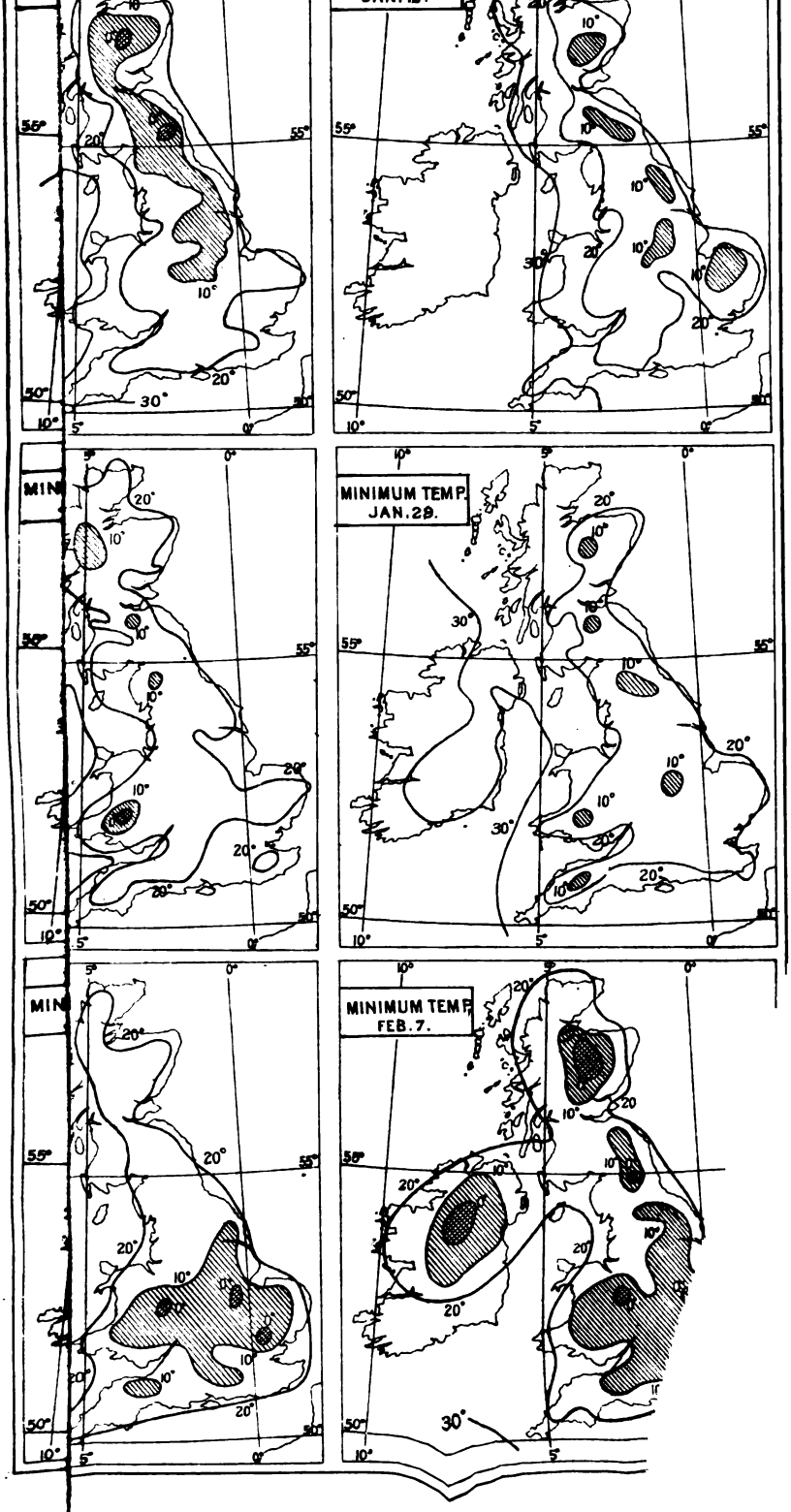

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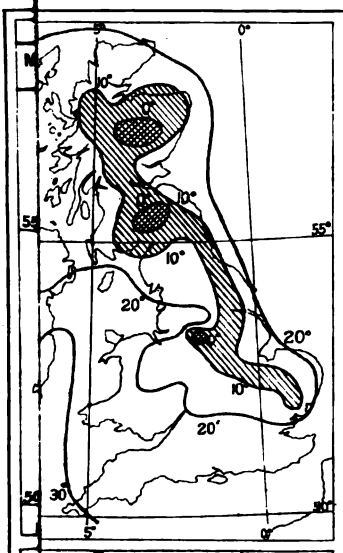

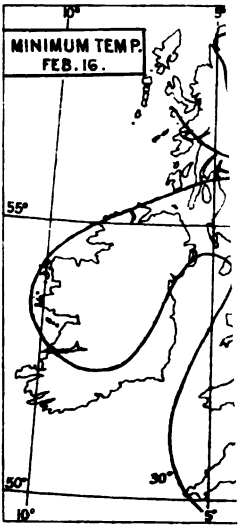

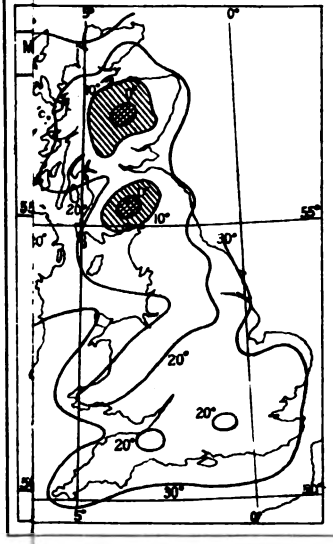

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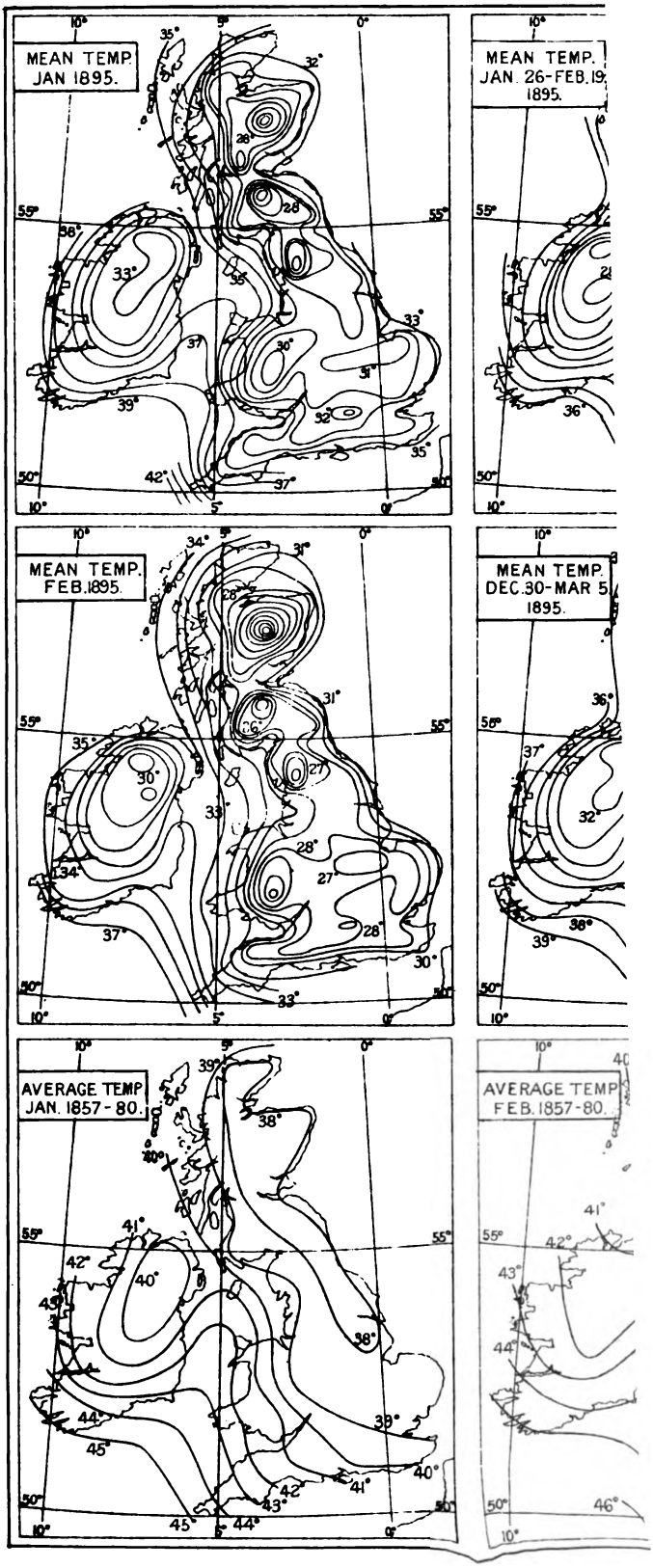
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ROYAL METEOROLOGICAL SOCIETY.

EDITED BY A

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OCTOBER 1895.

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SESSION 1895-6.

ORDINARY MEETINGS at 7.30 p.m.

November	20, 1895	March	18, 1896
December	18 ,,	April	15 ,,
January	15, 1896	May	20 ,,
February	19 ,,	June	17 ,,

ANNUAL GENERAL MEETING,

January 15, 1896.

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QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY.

VOL. XXI. OCTOBER, 1895. No. 96.

THE NOVEMBER FLOODS OF 1894 IN THE THAMES VALLEY.

By G. J. SYMONS, F.R.S., and G. CHATTERTON, M.A., M.Inst.C.E.

(Plate 6.)

[Read May 15th, 1895.]

THE mass of data upon this subject is so great, that it is only by classification and by division of labour that it can be brought before the Society in anything even approaching a complete form.

Our paper will therefore be divided into the following sections:—

(1) Notes upon the flood of November 1894, and on previous floods.
(2) Tabular list of the dates of recorded floods.
(3) Chronological list of, and notes upon, Thames floods.
(4) Damage in 1894.
(5) Relative heights of the principal floods since 1750.
(6) The rainfall which produced the flood of 1894.
(7) Rate of progress of flood down the river.
(8) Levels of the flood of 1894, and calculations as to the volume discharged.

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There is another preliminary statement which we desire to make, viz. our indebtedness to the Thames Conservancy Board and to its Engineer for unreservedly placing at our disposal the official records. We have purposely thrown the Conservancy Records into tables separate from those containing data otherwise obtained, and it is satisfactory to find that upon points respecting which information is afforded by both sources, the agreement is generally as close as could be expected, when we remember that the Thames, throughout the 150 miles of its course from its source until it reaches Teddington, has not a single automatic recorder of its height.

(1) *Notes upon the Flood of November 1894 and on previous Floods.*

(Contributed by various correspondents, collected from various sources, and arranged approximately from the head of the river downwards to Teddington.)

HUNGERFORD.—The floods here exceeded all previous records; they decreased rapidly on the 15th, and by 10 a.m. on the 16th the streets were nearly clear.

OXFORD, MAGDALEN COLLEGE LABORATORY.—The height of the Cherwell is taken at 10 a.m. daily near Magdalen Bridge, our zero being 178·90 ft. above Ordnance datum. The highest floods since January 1st, 1877, have reached the following altitudes:—

ft.	ft.
1877, Jan. 5—184·55	1882, Nov. 10—184·15
1880, Feb. 21—184·13	1883, Feb. 12—184·95
,, Oct. 9—184·05	1887, Jan. 21—184·30
1881, Dec. 20—184·04	1894, Nov. 16—184·56
1882, Oct. 26—184·90	

The floods of October 26th, 1882, and of February 12th, 1883, were therefore about 4 inches higher than the recent one, but no other was equal to it. The daily values from October 23rd to November 30th, 1894, were as under:—

ft.	ft.	ft.
Oct. 23—179·01	Nov. 5—182·05	Nov. 18—183·65
,, 24—179·89	,, 6—181·66	,, 19—183·33
,, 25—179·51	,, 7—181·26	,, 20—182·97
,, 26—179·67	,, 8—181·50	,, 21—182·70
,, 27—180·20	,, 9—181·59	,, 22—182·44
,, 28—180·58	,, 10—181·62	,, 23—182·24
,, 29—180·79	,, 11—181·52	,, 24—181·94
,, 30—180·82	,, 12—181·64	,, 25—181·60
,, 31—181·45	,, 13—182·61	,, 26—181·21
Nov. 1—181·77	,, 14—182·99	,, 27—180·97
,, 2—182·10	,, 15—184·40	,, 28—180·74
,, 3—182·39	,, 16—184·56	,, 29—180·62
,, 4—182·26	,, 17—184·08	,, 30—180·42

J. J. Manby.

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OXFORD.—The following are the levels of the floods of 1891 and of 1894, referred to Ordnance datum :—

	1891. ft.	1894. ft.	Excess. ft.
King's Weir, 2¼ miles NW ...	194·85	195·10	·25
Godstow Lock, 1½ miles NW ...	190·78	191·03	·25
Mean of 8 records in the City ...	187·56	188·26	·70
Water Works	183·41	184·80	1·39
New Hinksey	182·52	183·60	1·08
Iffley Road	181·79	183·30	1·51
Iffley Lock	181·85	182·74	·89
Kennington	180·10	181·90	1·80

W. H. White, C.E., City Engineer.

OXFORD.—The flood of 1894 was highest on Friday (16th). Here the 1875 flood was much greater than that of 1852.

ABINGDON.—The rainfall measured at the Sewage Farm at 4 p.m. was :

	ins.	
Nov. 12th ...	1·58	8·65 ins. in three days.
,, 13th ...	·40	
,, 14th ...	1·72	
,, 15th ...	·09	
	8·74	

The level of the water in the Thames, from information supplied by the respective surveyors, was :

Town.	Normal Level. ft.	Flood Level. ft.	Rise. ft.	Date. Nov.
Oxford	179·60	183·30	3·70	16th
Abingdon[1]	162·00	168·96	6·96	16th
Reading	120·50	127·32	6·82	
Henley	...	...	6·25	16th
Maidenhead	73·62	81·56	7·94	17th
Windsor	58·86	67·73	8·87	

The level of the Ock river, in Ock Street, on November 16th was 172·22 ft. above Ordnance datum, and that of the Stert stream, near the Railway Station, on the 14th was 176·87, and the flooding at Abingdon was due rather to the volume of water brought down by these streams than to that brought down by the Thames.

At Abingdon Lock the 1894 flood was 4 ins. above that of 1875.

At Clifton Bridge the 1894 flood was 6 ins. above that of 1875.

G. Winship, C.E., Boro' Surveyor.

LONG WITTENHAM.—The following have been the principal floods for nearly 200 years. The heights are the heights above high water mark :—

1764, Jan. 14 —The greatest for 80 years.

1768, Dec. 8, 7 ft. 7½ ins.—Rapid thaw after snow; greatest for 80 years.

[1] Opposite St. Helen's Church.

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1774, Mar. 10, 8 ft. 1 in. —Greatest for a century; carried away Henley Bridge.
1809, Jan. 27, 9 ft. 1 in. —Greatest on record, 5 ins. above 1894.
1821, Dec. 26? 8 ft. 10 ins.
1852, 7 ft. 10 ins.
1875, Nov. 15, 8 ft. 1 in.
1894, Nov. 16, 8 ft. 8 ins.

In 1894 the level was nearly uniform from 10 a.m. to 4 p.m. on 16th, but the absolute maximum was at 4 p.m. In 1875 the flood was also highest at 4 p.m., but on the 15th, not on the 16th. *F. C. Clutterbuck.*

Little Wittenham.—Here the 1894 flood exceeded that of 1821 by 4½ ins., but it was 7½ ins. below that of 1809. *F. C. Clutterbuck.*

Dorchester.—1894 flood not so high as 1809, but 5 ins. above 1821.

Shillingford.—In the malthouse wall by the riverside are two stones—one records the level of the flood of December 3rd, 1768, and the other (1 ft. 6½ ins. higher) that of January 27th, 1809. The flood of 1894 was 7 ins. above that of 1768, and 11½ ins. below 1809; it exceeded that of 1852 by 1 ft. 5 ins., and that of 1875 by 2 ft. 4 ins.

Preston Crowmarsh.—The 1809 mark at "The Swan" was not reached by 1 ft. 9 ins.

Wallingford.—The highest point in 1894 was 151·40 ft. above Ordnance datum, or 10 ft. 6 ins. above summer level. At Rush Court the 1894 flood was 12 ins. below that of January 27th, 1809, and 14 ins. above that of 1875. Below Wallingford Bridge the excess above 1875 was greater, being 17½ ins.

Goring.—The flood in 1894 was highest on the night of the 15th, and until 2 a.m. on the 16th; it was about 11 ft. above ordinary level.

Whitchurch.—The following notes are in the Register of this Parish:—

1765, November. A greater flood than ever known.

1770, February. Another flood, but 4 ins. lower.

1774, February (? March). A flood 14 ins. higher than either of the above.

1809, January. A very high flood.

By the description of the local marks which the flood of 1809 attained, it may be judged that 1894 was the exact counterpart. The contributing cause of the late flood was—that all the local small streams were greatly overcharged by the first fall on November 12th of 1·56 in., before they had discharged came the second fall of 1·60 in. with a repetition by the brooks just as the head waters of the Thames delivered the accumulation from above. On Thursday, 16th, at 4 p.m., I had seen my neighbour's horses put up in my stables without reason for fear, and at 9 p.m. the horses were standing a foot deep in water. This height continued till Saturday, 17th, when a marked decline was visible, which rapidly increased. *J. Slatter.*

Mapledurham.—On the 15th, at noon, the water in the Parish Church was several inches above the mark of the 1764 flood.

Reading.—In the register of St. Mary's Parish, it is stated that on Jan-

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uary 18-19, 1678, there was a greater flood than could be remembered by any person then living. The ordinary level of the Kennet above the weir at the pumping station is 116·25 ft. above Ordnance datum; in 1891 it rose to 122·03 ft., and in 1894 to 122·78 ft., or an excess of 9 ins. above 1891. The flood of November 17th, 1852, was 2 ins. higher than that of November 16th, 1875. At Caversham Bridge the ordinary summer level is 120·50 ft. above Ordnance datum, in October 1891 it rose to 124·82 ft., and on November 16th, 1894, to 126·05 ft.

Sonning.—The great floods of this century have been—

1809				
1821				
1852	Nov. 17	...	3 ft. 8 ins.	above high water mark
1875	Nov. 16	...	3 ft. 5 ins.	
1882	Oct. 28	...	3 ft. 8½ ins.	
1891	Oct. 24	...	3 ft. 2 ins.	
1894	Nov. 16	...	4 ft. 2 ins.	

I have not the precise figures for the early years, and owing to changes in the river they would not be strictly comparable. *J. Witherington.*

Henley.—The flood in 1894 rose 1 foot during the night of November 17th, and began to fall on the 18th. It was 12½ inches less than that of 1809, but 14 inches greater than that of 1852. *R. Pratt*, Boro' Surveyor.

Marlow.—The flood was highest on the 17th, and fell on the 18th. It was well above those of 1852 and 1875.

Bourne End.—The 1894 flood was 6 or 8 inches higher than that of 1852, and higher than known by any person now living. *E. Townsend.*

Cookham.—The flood at 4 a.m. on 18th (? 17th) was 9 inches above any existing record.

Boulter's Lock.—The flood was highest at 2.15 a.m on 17th; it was 5 ft. 3 ins. above high water level, and 1 foot higher than previously recorded.

Taplow.—The 1894 flood was from 5 to 12 inches above that of 1852.

Maidenhead.—The following levels were taken as under:—

Oct. 2, level of river			70·62 ft.	above Ordnance datum.
Nov. 1	,,	,,	75·42 ,,	,,
,, 15	,,	,,	80·00 ,,	,,
,, 16	,,	,,	81·00 ,,	,,
,, 17	,,	,,	81·56 ,,	,,

The flood was from 6 to 8 inches above that of 1852.

W. Fletcher Robinson, C.E.

Slough.—At the Waterworks the river rose 22 inches between the night of the 17th and 6 a.m. on the 18th.

An engineer reports that the 1894 flood was 4 inches above that of 1852, and 13 inches above that of 1877. *G. Bentley.*

Windsor.—Higher than any previous record, the nearest being in 1742, which was a few inches less.

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ETON.—In the College buttery is marked the level of the flood of March 10-11, 1774; the flood of 1894 did not reach it by 4½ inches.

R. F. Grantham, C.E.

STAINES.—The 1894 flood here was 10 inches below that of 1821. The following are the flood levels at Staines (of 51 ft. and upwards) as given in the Appendix to the *Report of the Select Committee on Thames Floods Prevention* (1877), but referred to Ordnance datum;—

	ft.	in.		ft.	in.
1821—	52	6	1841,	51	1
1828—	52	3	1852, Nov. 18—	51	8
1824—	51	3	1875, ,, 17—	51	6
1828—	51	2	1877, Jan. 11—	51	5
			1894, Nov. —	51	8½[1]

R. F. Grantham, C.E.

CHERTSEY.—Flood just equal to that of 1852.

SHEPPERTON.—The 1894 flood was five inches above that of 1821.

SUNBURY.—The 1894 flood is said to have been the highest since 1742, 4 inches above that of 1821, and 3 inches above that of 1852.

E. MOLESEY.—The flood in the Mole was highest on November 14th, that in the Thames on the 18th. This flood was several inches higher than that in 1877. *M. C. Jenkyns.*

E. MOLESEY.—The flood was highest from 9 a.m. to noon on the 18th; it was 14 inches above that of 1877, but 8½ below that of 1821.

HAMPTON.—There is a tablet at the base of Mr. T. Green's house (Old Ferry House) which records the level of the flood of March 1774, but this was not reached by about a foot.

At Spring Grove Wall the record of the 1852 flood was submerged 9 ins.

KINGSTON.—The flood was 11 ft. 6 ins. above summer level, and 7 inches higher than that of 1877.

TEDDINGTON.—The flood was above all recent ones, but 10 inches below that of 1821.

Below Teddington, therefore tidal.

TWICKENHAM.—A greater flood than that of 1875; it was highest at the top of the evening tide on November 18th. There is a mark here of the flood of March 1774; that mark is 21 ft. 9½ ins. above Ordnance datum, the recent flood did not reach it by 2 ft. 9½ ins. *G. B Laffan, C.E.*

(2) *Tabular List of the Dates of recorded Floods.*

Note.—As far as possible these dates are those of land floods. In London damage has frequently resulted from high tides. The present paper deals with land floods above Teddington, and therefore above the reach of the tides; some of the very early entries may refer to tidal injury, but all known cases have been excluded.

[1] This last was taken by myself at the railway bridge over the river.

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Year.	Date.	Year.	Date.	Year.	Date.
9	—	1765	Nov.	1866	Jan. 18
48	—	1768	Dec. 8	1867	Mar. 27
479	—	1770	Feb.	1869	Jan. 9
978	—	1774	Mar. 10-11	,,	Dec. 20
1099	—	1795	Feb. 12	1872	Jan. 26
1240	—	1809	Jan. 27	,,	Dec. 17
1555	Sep. 21	1821	Dec. 26	1875	Nov. 15-18
1564	Sep. 20	1823	—	1876	Dec. 9
1660	Nov. 11	1824	—	1877	Jan. 11
1673	Jan. 18-19	1828	—	1882	Oct. 28
1680	June	1836	—	1883	Feb.
1742	—	1841	Jan. 16	1891	Oct. 24-25
1763	—	1852	Nov. 17-18	1894	Nov. 16
1764	Jan. 14	1853	July 18		

(3) *Chronological List of, and Notes upon, Thames Floods.*

A.D. **9.**—The earliest recorded Thames flood. It is said to have overflowed the banks, and destroyed many inhabitants.

48.—The Thames overflowed, the waters extended through four counties, 10,000 persons were drowned, and much property was destroyed.

479.—The Thames much flooded, both above and below London; great damage.

973.—Thames greatly overflowed, many persons drowned.

1099.—Thames greatly flooded on festival of St. Martin.

1240.—Thames greatly flooded from rains. Extended above 6 miles at Lambeth.

1555.—Sept. 21st, great flood in the Thames owing to excessive rains. It overflowed its banks, and Westminster Hall was flooded.

1564.—Sept. 20th, Thames greatly overflowed.

1660.—Nov. 11th, great floods in the Thames valley.

1680.—June, great floods at Oxford.

1762.—Great flood in the Thames valley.

1763.—The vast extent of meadow from the source of the Thames to the river's mouth was almost covered with water.

1764.—In the Register book of Bicester is a note that "It began raining June 19th, 1763, and continued mostly wet weather till the beginning of February 1764; and [there] was a perpetual flood for the most part of November, December, and January, 15 weeks." A report from Abingdon dated February 11th, 1764, states that great distress prevailed among the bargemen, as they had not been able to work for two months, by reason of the floods, and one from Oxford ten days later (February 21st) says that the first barges started that day as the floods have so much abated.

1768.—Heavy rains at the end of November. On December 1st the Thames at Reading rose 2 ft. 6 ins. in less than half an hour, to a point

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higher than had been observed for 80 years. The Kennet and Loddon overflowed their banks. Burfield Bridge and part of Twyford Bridge were washed away. The Isis at Oxford rose 1 ft. 6 in. above any existing high water mark. The Exeter coach with six passengers and four horses was carried away by the flood near Staines, and all were drowned. The flood there was so excessive that 1,000 men were engaged in making drains to carry it off.

1774.—March 12th, great flood in the Thames, partly tidal but chiefly due to excessive rain. At Chesham and at Amersham (both in Buckinghamshire) a boat could be rowed through the town and the water rose 1 ft. above any previous flood. One farmer lost over 400 sheep. At Sandford, 3 miles from Oxford, and at Shillingford the brook was so swollen that a horse could swim over the high road. The West Country coaches were stopped at Slough and Staines. A chaise and pair of horses were washed away from Windsor. At Kingston the water reached the Town Hall, and it undermined the church, doing damage to the extent of £300, and it also tore open some graves. At Teddington the water reached the church, and rose in it to a considerable height. It did not actually flood Westminster Hall, but was within a few feet of it; nearer in fact than for forty previous years.

1795.—Heavy flood in the middle of February. At High Wycombe inhabitants had to take to upper rooms. At Maidenhead carriages could pass through the flood only by opening the doors and letting the water flow through. At Staines the Thames on the 12th was 9 ins. higher than on the 11th, and it was so high that the Southampton coach was upset. At Colnbrook, owing to the road being covered, four vehicles were upset, viz. the Gloucester and the Windsor coaches, a chaise and a waggon. At Hampton and Sunbury much land was under water, and boats were used in the streets of Kingston.

1809.—Flood at the end of January, due to rain melting deep snow. At Stony Stratford, on the 29th, a waggon and team were overturned by the flood and the driver and nine horses were drowned. So deep was the "brook" that not a vestige of the waggon could be seen, and it was six hours before the accident was discovered. A farmer going from Windsor to Stoke was washed into a field with his cart and horse. He was rescued by a boat. H.M. George III. had to remain at Windsor, as the ford at Datchet was impassable, and Eton Bridge had been carried away.

There was a flood four days previously (January 25th) which carried away bridges at Deptford and Lewisham, but it may have been tidal.

1809.—Another flood occurred at the end of April. On the 26th the Windsor coach was overturned into the water on the Eton College playing fields. Boats were used in the streets, and the King had to go to London by Egham and Staines, as the road through Slough was flooded.

1821-2.—Flood in the last days of December 1821. The Kennet and the Thames overflowed to a greater extent than for 15 [?12] years. The road from Reading to Caversham was impassable, one bridge being carried away, and all communication with Oxford was stopped. At Pangbourne some houses had several feet of water in their ground-floor rooms. The

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flood at Maidenhead was about the same as in 1795, but not so high as about 86 years ago [? 1774]. At Henley it was said to be the highest since 1809. There was no communication between Egham and Staines except by boat. On December 29th the water reached half way up the market place at Kingston.

1823.—A sudden flood at the beginning of November. Seventy sheep were drowned near Aylesbury. The flood at Oxford was reported to be on November 1st higher than remembered, at Windsor also it was said to be the greatest for many years, Eton was surrounded and no one could traverse the streets except in a cart or boat, Windsor Little Park was flooded and no carriages could reach Windsor from Datchet.

1841.—January 16th. Heavy snow was lying over much of the Thames valley, but there seems to have been, besides a thaw, some exceptional rain or bursting of a bank near Cranbourne (2 miles south of Windsor), for in the course of half an hour after 9 p.m. so much water poured into Windsor that many of the streets were 4 ft. deep. At the Adelaide Hotel in Sheet Street, in less than 10 minutes from the first indication of a flood the cellars were completely filled. The flood continued to rise gently till about 1 a.m., and then subsided. A policeman hearing dogs crying called up the owner, who found his stable with 4 ft. of water in it, the horse in great distress, and the two dogs nearly exhausted with swimming and barking. The flood covered the Eton playing fields about 8 ft., and there were also considerable floods near West Drayton.

1852.—The Duke of Wellington's flood, which was general over the country, was one of the great ones in the Thames. A correspondent at Charlbury, Oxon., said (referring probably to November 12th to 19th). "The Evenlode Valley has for more than a week been like an immense lake." Of Oxford on November 15th it was said, "This city stands literally in a sea of water, the whole of the surrounding country being flooded." The report from Reading (18th?) says, "No parallel flood has occurred since 1841, and none exceeding it except that in 1809, which was produced by the sudden melting of deep snow. The Thames was highest on November 17th, but the Kennett was higher on November 28th. Caversham lock was much damaged." At Windsor (on 15th?) part of the Home Park was 4 ft. under water, but even that was exceeded 12 years ago (*i.e.* in 1841). After about the 19th the flood decreased until the 23rd, but then it turned to rise, and on the 25th was as high as ever. At Putney the towing path was 6 ft. under water. Four miles of the Great Western line was flooded between Hanwell and Paddington.

1853.—Excessive rain on July 13th and 14th, producing floods and washing away much hay. For miles on the eastern side of Banbury little but water could be seen, the Cherwell soon overflowed, and one of the mills was more deeply flooded than it had been for 50 years. In passing Reading it flooded much of the town, and at Swallowfield the meadows were under 8 ft. of water. This flood appears to have been even more disastrous on the Ouse, north-east of the Thames basin.

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1866.—Slight floods at Oxford and in the Thames between January 19th and February 10th.

1867.—Thames over its banks at Windsor on March 27th.

1868.—On December 29th, Christ Church Meadow, Oxford, was under water, and so was most of the low-lying land near the river.

1869.—Heavy rains in the first week of January produced considerable floods. Much land flooded near Reading. A horse and cart were washed away near Caversham, and at Sonning and Twyford the floods were reported as higher than for many years. The highest point at Maidenhead seems to have been on January 9th.

1869.—Slight floods were produced about December 20th by rain during the previous week.

1872.—A considerable flood in Christmas week. Oxford was surrounded by water, punts had to be used in some of the streets of Windsor and Eton, but the flood there was reported as 2 ft. below that of 1852. At Maidenhead it was reported as higher than any since 1852.

1875.—July 15th-23rd. This was the period of the great Monmouthshire floods, and the Thames basin, though not suffering with equal severity, had a very heavy rainfall. Houses flooded in many districts, and railway traffic interrupted.

1875.—November 10th-17th. A very heavy flood due to continuous rains, producing, along the lower parts of the river, higher floods than had been reported since 1852.

1877.—January 11th. A high flood which had been accumulating from about Christmas reached its maximum on this day, and very nearly equalled the flood of 1852. There was the usual discomfort and injury in the upper part of the river, and as it synchronised with a very high tide, there was great destruction in Southwark and all low-lying places along the river.

1882.—October 24th. Heavy rains in the middle of October, resulting in considerable floods and consequent destruction of property.

1891.—October 25th. An extremely wet month, floods rose steadily and at Oxford were highest on 25th.

(4) *Damage in 1894.*

With reference to the damage done by the 1894 flood, it is impossible to enter into details. It would be an endless repetition of the story of flooded homes, spoiled furniture and provisions, of food, coals and letters conveyed by boats, and delivered into upper windows. We ourselves visited many of the houses which had had from 2 to 4 ft. of water in the sitting rooms. We heard of one where the billiard room was filled almost up to the ceiling. And these were not isolated cases, but streets, and roads, and crescents, we might almost say towns, have been built upon land which the slightest inquiry would have shown was far below the flood level of 1821, and therefore unfit for human habitations of the usual kind. One of the sad and yet ludicrous features of a visit to the flooded districts was to see, rising through

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TABLE I.—Excess or Defect (in feet and inches) of previous Flood Heights above that of 1894, from various sources.

Station.	1764.	1765.	1768.	1770.	1774.	1809.	1821.	1823.	1824.	1828.	1841.	1852.	1875.	1877.	1882.	1891.
Magdalen Bridge, Oxford	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	— ·10½
Long Wittenham	..	..	—1·0½	..	— ·7	+ ·5	+·2	..	..	..	..	— ·10	— ·7	..	..	..
Clifton Bridge	..	..	..	..	..	..	..	..	..	..	..	..	— ·6	..	..	..
Little Wittenham	..	..	..	..	..	+ ·7½	—·4½	..	..	..	..	..	..	..	..	..
Dorchester	..	..	..	..	..	+	—·5	..	..	..	..	..	..	..	..	..
Shillingford	..	..	— ·7	..	..	+ ·11½	..	..	..	..	..	—1·5	—2·4	..	..	..
Rush Court	..	..	..	..	..	+1·0	..	..	..	..	..	..	—1·2	..	..	..
Preston Crowmarsh	..	..	..	..	..	+1·9	..	..	..	..	..	..	..	..	..	..
Below Wallingford Bridge	..	..	..	..	..	..	..	..	..	..	..	..	—1·5½	..	..	..
Whitchurch	..	(—2·2)	..	(—2·6)	(—1·0)	·0	..	..	..	..	..	..	..	..	..	..
Mapledurham	..	..	(—·6)	..	..	..	..	..	..	..	..	..	..	..	..	..
Caversham Bridge	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	—1·3
Sonning	..	..	..	..	..	..	..	..	..	..	..	— ·11	— ·9	—1·0½	—·10½	—1·0
Henley-on-Thames	..	..	..	..	..	+1·0½	..	..	..	..	..	—1·2	..	..	..	..
Bourne End	..	..	..	..	..	..	..	..	..	..	..	— ·7	..	..	..	..
Taplow	..	..	..	..	..	..	..	..	..	..	..	— ·8½	..	..	..	..
Maidenhead	..	..	..	..	..	..	..	..	..	..	..	— ·7	..	..	..	..
Slough	..	..	..	..	..	..	..	..	..	..	..	— ·4	..	—1·1	..	..
Windsor	..	..	..	..	..	..	..	..	..	..	..	—1·2	—1·4	—1·3	..	..
Datchet	..	..	..	..	..	..	..	..	..	..	..	—1·0	..	..	..	..
Eton	..	..	..	..	+ ·4½	..	..	..	..	..	..	..	..	..	..	..
Staines	..	..	..	..	..	..	+·9½	+·6½	—·5½	—·6½	—·7½	— ·0½	— ·2½	— ·3½	..	..
Chertsey	..	..	..	..	..	..	..	..	..	..	..	·0	..	..	..	..
Shepperton	..	..	..	..	..	..	—·5	..	..	..	..	..	..	..	..	..
,,	..	..	..	..	..	..	—·8	..	..	..	..	..	..	..	..	..
Sunbury	..	..	..	..	..	..	—·4	..	..	..	..	— ·3	..	..	..	..
Molesey	..	..	..	..	..	..	+·6	..	..	..	..	..	..	..	..	..
,,	..	..	..	..	..	..	+·8½	..	..	..	..	..	..	—1·2	..	..
Hampton	..	..	..	..	+1·0	..	..	..	..	..	..	— ·9	..	..	..	..
Kingston	..	..	..	..	..	..	..	..	..	..	..	..	..	— ·7	..	..
Teddington	..	..	..	..	..	..	+·10	..	..	..	..	..	— ·7	..	..	..
Twickenham	..	..	..	..	+2·9½	..	..	..	..	..	..	..	..	..	..	..

Therefore the 1894 flood was equalled or exceeded only in 1774, 1809, 1821 and 1823.

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the water in dozens of localities, posts bearing large posters announcing "Eligible building land to let." Doubtless by this time some energetic speculator is busy erecting thereon a "rheumatic trap" on what now looks beautiful in its mantle of green and of flowers, and he is tolerably sure to find some young couple to take possession of it and find too late that beauty is not everything. That the local authorities ought to pass such plans and to undertake to sewer such roads we deny; but they have done so, and untold misery is the result.

(5) *Relative height of the principal Floods since 1750.*

Our next tables are adapted for reference rather than for reading aloud. They both have one object, that of showing the relation of the height of the 1894 flood to that of previous floods, and they differ only in this, that one is compiled from a variety of sources, and attempts to go back more than 130 years; the other is compiled entirely from data supplied by the Thames Conservancy, and deals almost exclusively with the floods of the last 20 years. Roughly the result is to show (as might have been expected) that each flood has, so to speak, an individual character; some are very high in one part of the river, others in another. For instance, the 1894 flood seems to have been lower than that of 1821 near Oxford, Staines, and Teddington, but higher at Long Wittenham and near Shepperton. Again, the 1774 flood was unimportant in the Upper Thames, but it carried away Henley Bridge, and in the vicinity of Teddington was far above 1894 or any other on record.

Taking, however, a general view of all the facts, we think that it is certain that the 1894 flood was the greatest for 70 years.

(6) *On the Rainfall which produced the Flood of 1894.*

The heavy rain at the end of October did not do much mischief, and it had nearly all passed Teddington before the second heavy rain came, but that found the soil thoroughly saturated, and therefore produced that "water running off water" which is well known as a great factor in producing floods, and the recent disasters are but one more illustration of the inevitable resultant mischief.

The Tables give the following information :—

Table II. The relation of the total of September, of October, and of November to the mean at 10 stations, over the whole area—September was 17 % below; October 25 % above; November 60 % in excess.

Table III. The fall each day from October 23rd to November 18th at 50 stations (p. 202).

Table IV. The mean of the 25 western, of the 25 eastern, and of all the returns for each day.

(7) *Rate of Progress of Flood down the River.*

We expressed at the beginning of this paper our regret at the absence o automatic records of the flood levels, and this absence renders it impossible

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TABLE II.—Relation of the Rainfall of September, October, and November 1894, to the Average 1880-89.

Station.	September.		October.		November.		October and November.	
	Total.	Difference from Average.	Total.	Difference from Average.	Total.	Difference from Average.	Total.	Difference from Average.
	in.	in.	in.	in.	in.	in.	in.	in.
Marlborough, Mildenhall ..	2·40	— ·25	3·30	+ ·07	6·48	+3·08	9·78	+3·15
Lechlade	2·24	— ·19	4·41	+1·68	4·73	+1·65	9·14	+3·33
Newbury, Welford Park ..	3·12	+ ·48	4·04	+ ·82	6·29	+2·91	10·33	+3·73
Banbury, Bloxham	2·35	— ·33	3·54	+ ·51	3·66	+ ·66	7·20	+1·17
Oxford, Mag. Coll. Laboratory	1·80	— ·63	3·26	+ ·48	4·76	+2·13	8·02	+2·61
Alton, Ashdell	2·71	— ·48	5·07	+1·48	6·04	+2·08	11·11	+3·56
Winslow, Addington Manor ..	1·77	— ·90	3·07	— ·02	4·36	+1·43	7·43	+1·41
Slough, Upton	1·96	— ·51	3·76	+ ·89	3·16	+ ·55	6·92	+1·44
Dunstable, Kensworth ..	2·28	— ·52	3·49	+ ·05	5·75	+2·94	9·24	+2·99
Dorking, Abinger Hall ..	2·10	—1·05	5·50	+1·74	5·01	+1·31	10·51	+3·05
Means	2·27	— ·44	3·94	+ ·77	5·02	+1·87	8·97	+2·64

to state the rate at which the flood passed down the river. By this of course we do not mean the flow of the water itself, but the sequence in time at which the highest point occurred lower and lower down the river. And it must be remembered that we are not considering the rate of progress of a mass of water, suddenly released at the end of a single channel, but of the passage of a flood along the Thames, complicated by the inflow at many points of affluents, some of them nearly as important as the main river. The note from East Molesey, that the Mole was highest *four days* before the Thames, illustrates the difficulty (without a proper organisation) of computing and predicting the time and height of coming floods, but the problem has been solved for the Rhone, for the Seine, for the Loire, and for many rivers in

TABLE IV.—Average Rain over the Thames Watershed above Teddington, October 23rd to November 18th, 1894.

Date.	Twenty-five Westerly Stations.	Twenty-five Easterly Stations.	Fifty Stations, Daily fall.	Date.	Twenty-five Westerly Stations.	Twenty-five Easterly Stations.	Fifty Stations, Daily fall.	Date.	Twenty-five Westerly Stations.	Twenty-five Easterly Stations.	Fifty Stations, Daily fall.
	in.	in.	in.		in.	in.	in.		in.	in.	in.
October 23	·15	·09	·12	November 2	·11	·05	·08	November 12	1·25	·99	1·12
24	·61	·71	·66	3	·12	·20	·16	13	·84	·38	·61
25	·07	·04	·06	4	·01	·01	·01	14	·93	1·12	1·02
26	·65	·46	·55	5	·05	·06	·05	15	·04	·10	·07
27	·16	·20	·18	6	·01	·01	·01	16	·02	·07	·04
28	·44	·49	·46	7	·59	·55	·57	17	·01	·02	·02
29	·15	·13	·14	8	·07	·02	·05	18	..	..	..
30	1·05	1·09	1·07	9	·11	·12	·11				
31	·06	·05	·06	10	·12	·15	·14				
November 1	·25	·13	·19	11	·43	·50	·47	Total ..	8·30	7·74	8·02

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TABLE III.—Rainfall which produced the Flood on the Thames in November 1894.

Date.	Ashley Rectory [Tetbury.]	Cheltenham, Southam Villa.	Cirencester, Further Barton.	Broad Hinton.	New Swindon.	Faringford, Kempsford.	Fairford, Hatherop Rectory.	Bourton-on-the-Water.	Moreton-in-Marsh, Longborough.	Great Barrington.	Leechlade.	Marlborough, Millenhall.	Lambourne.	Banbury, Sibford Ferris.	Hungerford, Kintbury.	Newbury, Welford Park.	Abingdon Union.	Oxford, Mag. Coll. Laboratory.	Steeple Aston.	Grimsbury [Banbury].	Garsington.	Little Wittenham.	Yattendon Court.	Basingstoke, Sherborne St. John.	Alton, Ashdell.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
October 23	.20	.26	.18	.25	.16	.15	..	.34	.18	.16	.06	.06	.14	.14	.20	.17	.09	.26	.10	.11	..	.81	.08	.14	.34
24	.94	.40	.73	.45	.36	.95	.70	.50	.49	.60	.87	.60	.54	.41	.51	.48	.59	.60	.36	.32	.79	.12	.49	.87	.77
25	.12	.10	.03	.04	.05	.10	.02	.08	.08	.05	.03	.08	.03	.06	.06	.13	.03	.01	.03	.05	.14	..	..	.01	.35
26	1.20	.49	1.12	.98	.78	.68	.93	.85	.67	1.08	.80	.45	.45	.59	.42	.36	.28	.35	.85	.90	.28	.27	.15	.73	.81
27	..	.33	.23	.14	.24	.23	.10	.19	.25	.12	.22	.12	.12	.18	.09	.13	.06	.06	.09	.10	.03	..	.15	.34	.21
28	..	.53	.61	.54	.52	.34	.40	.60	.35	.41	.31	.36	.46	.29	.50	.44	.36	.27	.31	.26	.50	.41	.48	.52	.80
29	..	.19	.22	.19	.36	.13	.11	.03	.10	.15	.09	.08	.18	.04	.13	.14	.08	.08	.05	.05	.30	.35	.12	.13	.33
30	..	1.22	.75	1.04	1.28	1.41	1.43	.88	.78	.96	1.48	.94	1.25	.56	.98	1.20	1.32	1.01	.76	.43	.78	1.28	1.23	.84	.93
31	..	.08	.07	.10	.08	.07	.04	.08	.11	.08	.03	.10	.08	.06	.11	.08	.01	.18	.20	.05	.14	.08	.12	.09	.09
November 1	..	.45	.36	.41	.21	.18	.23	.36	.31	.35	.16	.51	.47	.29	.21	.18	.19	.18	.20	.19	.14	.08	.09	.21	.21
2	..	.04	.01	.05	.18	.20	.15	.06	..	.12	.27	.13	.14	.06	.14	.25	.13	.13	.12	.03	..	.07	.09	.09	.06
3	..	.10	.02	.06	.12	.03	.23	.15	.05	.26	.03	..	.02	.16	.16	.13	.01	..	..	..	..	.24	.41	.45	.20
4	..	.01	..	.02	.02	..	.01	.01	..	..	..	..	.03	..	.01	.03	.03	..	..	..	.12	..	..	..	.04
5	..	.01	.01	.01	.04	.05	.04	.03	..	.02	.05	.11	.12	.01	.17	.08	..	.06	..	..	..	..	.12	.04	.08
6	..	..	..	..	.01	.04	..	..	.03	.01	..	..	..	.01	.01	..	..	..	..	..	..	..	..	.01	.10
7	..	.57	.49	.68	.57	.38	.40	.39	.62	.55	.45	.39	.65	.56	.88	.78	.78	.98	.45	.45	.74	.54	.54	.73	.50
8	..	.17	.18	.20	.16	.07	.11	.20	.13	.10	.08	.02	.14	.01	.09	.10	.10	.05	.02	.07	..	..	.02	..	.14
9	..	.10	.03	.24	.11	.06	.11	.06	.16	.08	.15	.24	.07	.05	.11	.11	.12	.04	.08	.07	..	..	.14	.17	.14
10	..	.20	.18	.10	.15	.16	.11	.23	.14	.13	.10	.09	.07	.12	.14	.09	.05	.06	.07	.08	.11	.10	.13	.20	.27
11	..	.45	.17	.37	.80	.62	.36	.28	.16	.38	.30	.54	.73	.22	.56	.56	.46	.57	.26	.25	.83	..	.46	.52	.78
12	..	1.23	1.13	1.71	1.55	1.16	1.15	1.06	1.30	1.11	1.30	1.85	1.47	1.24	1.34	1.66	1.35	1.00	1.19	1.05	.79	1.12	1.25	1.05	.97
13	..	.95	.93	.80	.91	.69	1.04	1.38	1.03	1.00	.66	.51	.89	.75	.77	.74	.58	.79	.91	.68	1.17	.88	.62	.48	.80
14	..	.60	.41	.58	.98	1.02	.52	.44	.58	.78	1.10	1.49	1.40	.54	1.61	1.34	1.19	.73	.63	.40	.63	1.42	1.35	1.27	1.27
15	..	.06	.05	.01	.01	..	..	..	.02	..	..	.03	.01	..	.04	.03	.01	.02	.01	..	..	.27	.04	.14	.12
16	..	..	.02	.01	.03	.02	..	..	.02	..	..	.04	.05	.01	.04	.02	.01	..	.01	..	..	.04	.02	.04	.04
17	..	..	..	..	..	.01	.01	.01	..	..	..	..	.03	.01	.03	.04	.02	.02	.01	.02	..	.01	.01	.02	.01
18	..	..	..	..	.02	..	.02	..	..	..	..	.02	..	..	..	.	..	..	..	..	..	..	..	.01	.01
Total	..	6·59	5·76	9·69	9·04	8·49	8·21	8·38	7·36	8·20	8·42	9·00	9·58	6·37	9·51	9·27	7·72	7·27	6·58	5·49	7·35	8·03	7·95	9·10	10·37

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TABLE III.—Rainfall which produced the Flood on the Thames in November 1894—*Continued.*

Date.		Strathfield Turgiss.	Reading, Portland Place.	Henley-on-Thames, Northfield House.	Wallington, Fyfton Manor.	Winslow, Addington Manor.	Wendover, Halton Gardens.	Maidenhead, Hedsor.	Wokingham, Binfield Park.	Sandhurst Lodge.	Greatham, King's Holt.	Farnham, Great Down, Seale.	Chertsey, Ottershaw.	Slough, Upton Hall.	Amersham, The Plantation.	Great Berkhampstead, Roseberk.	Kensworth [Dunstable].	Cranleigh Common.	Ashtead, Abinger Hall.	D'Abernon Chase.	Kew Observatory.	Pinner Hill.	Watford, Frogmore.	St. Alban's, The Grange.	Welwyn Rectory.	Baigate, Woodbarton Lodge.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
October	23	.11	.20	.14	.05	.04	.11	.05	.09	.11	.68	.02	.:	.07	.05	.05	.04	.13	.05	.01	.08	.07	.07	.06	.06	.03
	24	.80	.61	.59	.52	.67	.68	.74	.77	.72	.51	.56	.50	.47	.69	.54	.51	1.39	1.62	1.20	.50	.52	.57	.62	.61	.79
	25	.02	.02	.03	.05	.02	.:	.03	.01	.01	(.13)	.12	.05	.:	.05	.03	.:	.04	.11	.10	.01	.01	.05	.01	.:	.07
	26	.53	.52	.48	.30	.41	.13	.32	.21	.43	(.60)	.73	.39	.30	.37	.41	.35	.75	.95	.53	.42	.37	.42	.34	.49	.49
	27	.22	.24	.19	.06	.08	.13	.24	.21	.34	.16	.17	.35	.33	.18	.09	.08	.20	.21	.47	.18	.19	.29	.12	.07	.26
	28	.40	.51	.44	.48	.35	.39	.49	.63	.66	.64	.47	.68	.57	.52	.50	.41	.37	.43	.44	.43	.56	.62	.64	.57	.19
	29	.16	.16	.16	.05	.04	.07	.13	.21	.14	(.24)	.16	.22	.07	.02	.03	.08	.24	.24	.28	.16	.12	.09	.05	.04	.20
	30	.99	1.43	1.44	1.22	.70	.85	1.30	1.40	1.25	(.80)	.79	1.47	1.35	.94	.84	.72	.95	1.04	1.56	1.36	1.10	.95	.90	.68	1.11
	31	.06	.06	.04	.03	.05	.04	.:	.07	.04	(.10)	.01	.02	.02	.08	.09	.09	.04	.06	.01	.:	.03	.02	.07	.12	.04
November	1	.15	.10	.06	.09	.27	.08	.13	.13	.11	.43	.18	.08	.08	.10	.08	.08	.17	.12	.10	.07	.15	.16	.14	.10	.19
	2	.04	.08	.06	.08	.12	.08	.07	.02	.03	.06	.02	.02	.01	.05	.07	.05	.05	.05	.02	.02	.03	.01	.03	.04	.04
	3	.35	.24	.23	.24	.04	.14	.29	.34	.24	.19	.12	.13	.10	.32	.22	.30	.21	.23	.29	.12	.17	.18	.12	.10	.06
	4	.:	.:	.:	.:	.:	.:	.:	.:	.01	.02	.:	.01	.:	.:	.:	.:	.01	.:	.:	.:	.:	.:	.:	.09	.:
	5	.04	.10	.09	.05	.02	.:	.15	.07	.02	.04	.07	.03	.01	.03	.01	.:	.04	.10	.21	.01	.12	.06	.01	.02	.09
	6	.01	.01	.:	.:	.:	.:	.:	.:	.01	.01	.:	.:	.:	.:	.:	.08	.03	.:	.01	.01	.:	.:	.01	.:	.01
	7	.62	.62	.59	.62	.78	.74	.57	.78	.56	.48	.39	.45	.47	.67	.62	.70	.40	.06	.45	.56	.35	.37	.63	.44	.49
	8	.07	.02	.03	.:	.:	.:	.:	.01	.02	.11	.:	.02	.:	.:	.:	.02	.:	.:	.01	.01	.03	.:	.:	.:	.:	.:
	9	.11	.13	.14	.09	.04	.14	.15	.11	.18	.12	.18	.13	.09	.13	.09	.07	.22	.21	.15	.08	.11	.12	.08	.06	.16
	10	.30	.12	.12	.20	.07	.12	.13	.18	.18	.21	.20	.12	.08	.14	.15	.09	.19	.21	.24	.13	.13	.15	.25	.:	.15
	11	.52	.49	.49	.52	.29	.54	.43	.47	.49	.83	.49	.43	.41	.46	.50	.55	.68	.17	.62	.46	.47	.47	.50	.45	.55
	12	1.25	.82	1.11	1.26	1.01	1.22	.78	.64	.77	.92	.82	.55	.93	1.18	1.62	1.68	.80	.64	.66	.49	1.00	.95	1.04	1.25	1.40
	13	.42	.47	.40	.47	.53	.47	.28	.25	.27	.73	.38	.22	.13	.40	.56	.55	.64	.58	.35	.17	.19	.26	.33	.34	.14
	14	1.19	1.18	1.18	1.51	1.02	1.33	1.05	1.25	.78	1.33	1.04	.75	.65	1.51	1.02	1.21	1.11	1.18	.87	.59	1.16	1.39	1.40	1.40	.94
	15	.08	.03	.01	.:	.:	.02	.15	.09	.09	.15	.17	.17	.09	.07	.02	.08	.20	.20	.28	.10	.11	.11	.08	.01	.26
	16	.03	.04	.04	.02	.01	.03	.02	.02	.04	.08	.06	.05	.02	.02	.01	.05	.39	.:	.08	.02	.02	.01	.01	.01	.28
	17	.01	.03	.02	.01	.01	.03	.03	.:	.01	.02	.:	.02	.02	.06	.06	.:	.01	.:	.03	.03	.06	.07	.03	.:	.03
	18	.01	.:	.:	.:	.:	.:	.:	.:	.02	.:	.:	.:	.02	.:	.01	.:	.:	.:	.01	.01	.:	.:	.:	.:	.01
Total		8·49	8·23	8·08	7·92	6·57	7·69	7·53	8·19	7·53	9·59	7·15	6·86	6·27	8·04	7·62	7·79	9·26	9·60	8·55	6·02	7·00	7·39	7·47	6·66	7·98

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(8) *Levels of the Flood of 1894 and Calculations as to the volume discharged.*

TABLE V.—Flood Levels of the River Thames. Furnished by the Thames Conservancy Board.

Name of Lock.	1774.	1809.	1821.	1852.	1875.	Nov. 1882.	Feb. 1883.	1894.	1894. Above the Summer Level at head of Lock.	
	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	in.
St. John's	..	..	..	..	..	..	..	237·08	3	3
Buscot	..	..	..	..	..	..	..	235·63	4	5
Eaton..	..	..	..	..	..	..	..	231·26	2	0
Radcot	..	..	..	..	..	..	..	225·40	3	6
Rushey	..	..	..	..	..	..	..	220·29	3	3
Northmoor	..	..	..	..	..	..	..	208·61	4	7
Pinkhill	..	..	..	..	..	..	..	202·80	3	0
Eynsham	..	..	..	..	..	..	..	200·25	3	10
King's Weir	..	..	..	..	..	..	..	195·39	1	10
Godstow	..	..	..	..	..	..	..	191·77	0	9
Medley	..	..	..	..	..	..	..	189·48	2	2
Osney	..	..	..	..	..	188·14	..	186·39	0	6
Iffley	..	..	..	..	..	182·41	182·25	182·79	2	10
Sandford	..	..	..	..	..	179·16	179·16	179·51	2	6
Abingdon	..	..	..	..	170·07	170·17	169·84	170·42	2	4
Culham	..	..	..	..	166·70	166·86	166·35	166·27	4	3
Clifton	..	..	..	..	159·86	159·87	158·37	160·79	6	10
Day's	..	..	..	..	..	156·55	154·79	157·35	6	8
Day's Lock House ..	..	..	157·05	156·05	155·68	..	..	..	..	
Benson Lock ..	..	..	..	..	151·80	150·94	150·68	153·01	7	6
Cleeve	..	..	..	..	..	..	..	144·35	5	1
Goring	..	..	..	..	..	..	..	143·24	6	9
Whitchurch	..	..	..	..	..	135·70	134·86	136·20	5	4
Mapledurham ..	..	..	..	..	130·74	130·98	130·77	131·67	4	3
Caversham	..	..	..	..	..	124·04	123·88	124·96	4	6
Blake's	..	..	..	..	..	..	..	122·96	3	6
Sonning	..	..	..	..	119·54	119·31	119·31	120·16	4	2
Shiplake	..	..	..	..	..	113·94	114·11	115·30	4	8
Marsh	..	..	..	..	109·50	109·10	..	110·06	5	6
Henley Bridge, above	..	109·81	..	..	..	..	..	108·73	..	
Henley Bridge, below	108·67	109·01	..	..	..	..	..	108·26	..	
Hambledon Lock ..	..	..	..	..	104·95	104·48	104·82	106·28	5	2
Hurley	..	..	..	..	99·21	98·99	99·07	100·07	3	4
Temple	..	..	..	..	..	96·50	96·83	97·97	4	9
Marlow	..	..	..	..	93·60	93·00	93·58	94·98	5	9
Cookham	..	..	..	..	87·03	87·17	87·33	88·13	5	10
Boulter's	..	..	..	..	82·16	81·87	82·20	83·18	5	3
Bray	..	..	..	..	77·27	..	..	78·31	8	3
Boveney	..	..	..	..	70·00	69·92	70·25	71·40	6	2
Romney	..	..	..	..	66·97	65·66	66·25	68·28	7	8
Old Windsor ..	..	..	..	..	60·99	61·19	61·27	61·91	8	0
Bell Weir	..	..	..	..	..	53·11	52·69	55·27	7	0
Penton Hook ..	..	..	48·01	..	46·81	..	..	47·64	5	7
Chertsey	..	..	41·46	..	41·23	..	..	41·43	2	11
Shepperton	..	..	39·26	..	37·48	38·37	38·62	38·55	4	5
Sunbury	..	..	33·64	..	31·08	32·13	32·96	34·42	7	0
Molesey	..	..	30·20	..	..	26·83	27·83	29·65	8	6
Teddington	..	..	23·09	..	..	19·39	20·13	22·14	6	7

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the United States, why should it not be done for the Thames? At Hungerford the streets were nearly clear of water on the morning of the 16th; at Abingdon the flood was highest in the afternoon of the 16th; near Windsor late on the 17th, but at Teddington it continued to rise until nearly noon on the 18th. We do not presume to quote any rate of translation, but evidently it was so slight that neither a telegraph nor even a horse was needed to have informed the inhabitants of E. Molesey of what was coming upon them.

If houses are to be built below flood level, surely the occupiers might be warned when to vacate their ground floors and have the piano carried upstairs.

TABLE VI.—Rainfall and Discharge for the Flood of November 1894.

Date.	1. Quantity passing over Teddington Weir. Millions of gallons per day.	2. Rainfall over Watershed equivalent to figures given in column 1.	3. Mean Daily Rainfall over the Watershed.	Date.	1. Quantity passing over Teddington Weir. Millions of gallons per day.	2. Rainfall over Watershed equivalent to figures given in column 1.	3. Mean Daily Rainfall over the Watershed.
		in.	in.			in.	in.
October 19	332·1	0·01	..	November 12	4,063·5	0·07	1·12
20	374·4	0·01	..	13	5,250·6	0·10	0·61
21	384·3	0·01	..	14	6,776·1	0·12	1·02
22	358·2	0·01	..	15	7,949·7	0·14	0·07
23	363·6	0·01	0·12	16	10,257 3	0·19	0·04
24	468·0	0·01	0·66	17	12,798·9	0·23	0·02
25	887·4	0·02	0·06	18	20,135·7	0·37	0·00
26	1,362·6	0·02	0·55	19	17,319·6	0·32	..
27	1,229·4	0·02	0·18	20	10,485·9	0·19	..
28	2,038·5	0·04	0·46	21	7,850·7	0·14	..
29	2,174·4	0·04	0·14	22	6,786·9	0·12	..
30	2,932·2	0·05	1·07	23	6,400·8	0·12	..
31	3,975·3	0·07	0·06	24	5,859·9	0·11	..
November 1	4,783·5	0·09	0·19	25	5,215·5	0·10	..
2	5,064·3	0·09	0·08	26	4,195·8	0·08	..
3	5,022·0	0·09	0·16	27	3,504·6	0·06	..
4	4 743·0	0·09	0·01	28	3,141·0	0·06	..
5	4,462·2	0·08	0·05	29	2,925·9	0·05	..
6	4,338·0	0·08	0·01	30	2,705·4	0·05	..
7	3,416·4	0·06	0·57	December 1	2,592·9	0·05	..
8	3,331·8	0·06	0·05	2	2,425·5	0·04	..
9	4,119·3	0·08	0·11	3	2,333·7	0·04	..
10	3,839·4	0·07	0·14	4	2,285·1	0·04	..
11	3,772·8	0·07	0·47	5	2,226·6	0·04	..
					Total	4·01	8·02

Particulars of Maximum and Minimum Flow of the River Thames.

	Gallons.
Minimum average daily flow for 14 days at Teddington Weir. (See *Report of Royal Commission on London Water Supply*, par. 78.)	281,000,000
Average daily discharge during nine years, 1883-91	1,862,581,288

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PARTICULARS OF MAXIMUM AND MINIMUM FLOW OF THE RIVER THAMES.

(Continued.)

	Gallons.
Maximum discharge in one day over Teddington Weir during flood (November 18th, 1894)	20,135,700,000
Ratios.	
Fourteen days' minimum to average for nine years	1 to 4·8
Fourteen days' minimum to maximum discharge of flood of November 1894	1 to 72
Average daily discharge for nine years to maximum discharge of flood of November 1894	1 to 15

DISCUSSION.

Mr. B. LATHAM said that he had been much interested in the paper which Messrs. Symons and Chatterton had prepared, and he hoped all the statistics given would appear in print in the *Quarterly Journal*, as much of the information afforded valuable records concerning floods in the Thames. It certainly appeared that modern floods were not greater than those in earlier years, although there was a popular belief that drainage and similar engineering works had increased floods. The records available, however, seemed to demonstrate that the reverse was the case. Mr. Brodie's account of the causes which produced the heavy rainfall which resulted in the floods was a useful contribution to the account of the floods in the Thames in November last year, and showed clearly that the excessive precipitation was entirely due to the movements of two secondary depressions.

Mr. R. W. P. BIRCH expressed his appreciation of the thorough manner in which the work involved in the preparation of the paper had been performed. He joined with Mr. Latham in entering a protest against the opinion which was popularly held that land drainage increased floods; such an idea was an utter fallacy. Probably the reason that people thought that floods were greater than in former years was due to the alteration in the character of many of the districts liable to be flooded, the localities which many years ago were meadow lands being now covered with dwelling houses, so the effects of a flood in such districts were more serious in modern times than formerly. Concerning the divergence between the line of mean hydraulic gradient and the water lines at various parts of the Thames (as shown in Mr. Chatterton's diagram), he said that such fluctuations were probably due to the nature of the soil which the river passed through, some being soft and some hard, and the bed of the river consequently not being equally parallel to that gradient in all places.

Major L. FLOWER, in supporting the remarks made by Mr. Latham and Mr. Birch concerning the effect of land drainage on floods, said that he could not understand how it could be supposed that land drainage caused floods, as the flow of water off undrained land must be more rapid than the flow from drained land. Floods were caused by excessive rainfall, on high ground, flowing into the rivers and swelling the stream. He thought that the differences between the dotted line and the flood level shown in red on the diagram were due, as Mr. Birch had said, to the variations in soil of the district and in the bed of the river.

Mr. E. K. BURSTAL said that he wished to emphasize the desirability of plotting the bed of the river on the diagram exhibited, as such information would be most valuable. He had been professionally connected with several engineering works in various parts of the Thames, and the paper had consequently considerable interest for him, as during the last November flood the copings of the new waterworks' filter beds at Oxford constructed by him were 2 ft. 4 ins. above the flood level, while at the Windsor Sewage Works on the Ham at Old Windsor the water was only one inch from the top of the copings of the precipitating tanks, the latter of these measurements not affording a sufficient margin for safety. He suggested that information concerning the changes which had

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been made in the bed of the river by dredging operations should also be obtained, so that such changes could be taken into consideration when comparing flood records of past and present times. There was one point in the river between Abingdon and Oxford where a great improvement had been made by the removal of a ridge of rock which formerly obstructed the channel.

Mr. R. F. GRANTHAM said that he disagreed with the remarks which had been made that because floods were as high in past years as they are now, it was to be concluded that land drainage and improvements in arterial drains did not increase floods. It must be remembered that great improvements had been effected in the river valley, and in consequence the water was now able to pass away more easily than formerly. He quoted the following table of the height of floods above Ordnance datum in the Upper Thames Valley and its tributaries above Wittenham in the years 1872 and 1875, and also alluded to some flood marks made by the Ordnance Survey on bridges in the district named.

Locality.	1872–3.	1875
	ft.	ft.
St. John's Bridge, Lechlade	236·08	236·68
Radcot Bridge	225·71	226·55
Tadpole Bridge	217·67	218·02
New Bridge	210·38	211·10
Chequers Inn, Babloc̈k Hythe	206·16	206·70
Swinford Bridge	199·45	200·26
Radley Railway Bridge	171·68	172·23
Kennington Railway Bridge	179·89	180·59
Medley Lock	188·96	189·36
Islip Bridge	194·67	194·94
Magdalen College, Oxford	185·34	185·76
Culham Railway Bridge, about 1½ mile above Long Wittenham	160·01	160·71

Rev. J. SLATTER said that the diagram exhibiting the longitudinal section of the Thames between Lechlade and Teddington was extremely interesting, but it might at the same time be misleading, as it must be remembered that the depth and volume of the river varied from mile to mile. For instance, between Wallingford and Reading the river nearly doubles in volume, and the late Rev. J. C. Clutterbuck had shown that this was due to the channel cutting through the chalk, and the river was thus fed from the springs. He pointed out that at Oxford, where the flood level seemed low, the observations were made on the river Cherwell at about a mile from its junction with the Thames, and so did not represent the condition of the Thames itself. Besides the length and depth, there were also these other essential elements in the treatment of the question, viz. the breadth of the channel and the velocity of the current. He considered that it would be easy for the Thames Conservancy to send warning of impending floods to those likely to be affected thereby, and he thought that the Board should be strongly urged to undertake this duty. From personal experience, extending over a number of years, he knew that at Reading the river was usually 36 hours rising after a heavy rainfall. One cause of increase the floods appeared to be that the water was kept in check till the mischief was imminent, and he thought that when the water was known to be coming facilities should be afforded to allow it to pass away freely. Floods were of much less duration in recent years than in earlier times, and the waterway sided in one-fourth of the time it formerly occupied.

Capt. D. WILSON-BARKER remarked that at Greenhithe no indication of floods were discernible.

Dr. A. BUCHAN commented upon the great lack of information concerning the height of floods in earlier years, and suggested that a good deal of useful information concerning floods might be accumulated if careful inquiries were made of people resident in localities liable to be flooded, and diligent search for any marks upon buildings or bridges. Dr. Buchan quoted an instance where a portion of a railway in Scotland had been destroyed by a flood. Subsequently, at the time the railway was projected inquiries were made concerning the heights of floods, and one old shepherd pointed out a height to which he had attained when he was a "laddie" as the highest he had known

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pointed out being remarkably high, the engineers discarded the shepherd's statement as being probably erroneous, and the railway was constructed, allowing only for a lower level as the maximum flood height. Forty years afterwards, a flood such as the shepherd had spoken of was experienced, and resulted in serious damage to the railway. Concerning the cause of the rainfall which gave rise to the floods of November 1894, he (Dr. Buchan) said that he remembered two marked cases of storms originating within the limits of the British Isles, and he would like to see the conditions of air temperature and humidity worked up in connection with the formation of such storms.

Mr. G. J. SYMONS, in reply, said that it was not easy to get at satisfactory evidence whether agricultural drainage did or did not increase floods, because it was impossible to be sure that the producing causes of any two floods were similar, and unless the causes were identical no fair comparison could be made. The height of the flood at Oxford, as shown on the longitudinal section, was supplied by the Thames Conservancy, and referred to the main stream of the Thames, but it agreed very closely with the height given in the table of the height on the Cherwell. The importance of the proper and systematic markings of flood heights could not be too earnestly urged upon the authorities, and it was difficult to understand why more was not done in that direction.

Mr. G. CHATTERTON said that the questions of the connection between agricultural drainage and floods had been carefully avoided in the present paper, it being considered that such matters could be more suitably discussed by the members of the engineering profession. Concerning the marking of flood heights, he understood it was the intention of the Thames Conservancy to suitably indicate the height attained by the flood of last November at the various points on the Thames, as shown in the longitudinal section. Mr. Slatter's idea concerning the method of getting rid of the excess of water would be quite impracticable, as the volume of water to be dealt with was so great. The amount of rainfall over the Thames Valley did not appear to be sufficient in itself to account for the November floods, and it would seem probable, in order to account for the present increase in the amount discharged from November 17th to 18th, of over 7,000,000,000 gallons, that there were certain obstructions by fences and the like which up to a certain period held up the water, but, suddenly collapsing, caused the water to rush with irresistible force towards the main body of the stream.

Mr. J. W. RESTLER, in a communication to the Secretary, furnished the following list of levels to which the water rose at various times between November 14th and 22nd, opposite the Southwark and Vauxhall Water Company's works at Hampton.

RIVER LEVELS DURING FLOOD TAKEN AT SUNNYSIDE, HAMPTON.
Ordinary Summer Level 21·92 ft. above Ordnance Datum.

1894.	Time.	Ordnance Datum.	1894.	Time.	Ordnance Datum.
		ft.			ft.
November 14	7.30 a.m.	25·30	November 16	2.0 p.m.	28·41
,, ,,	9.0 ,,	25·44	,, 17	7.15 a.m.	29·48
,, ,,	2.30 p.m.	25·45	,, ,,	4.0 p.m.	30·19
,, 15	7.30 a.m.	26·43	,, 18	7.30 a.m.	31·02
,, ,,	9.0 ,,	26·52	,, 19	9.15 ,,	30·48
,, ,,	3.30 p.m.	26·91	,, 20	9.0 ,,	29·10
,, 16	7.0 a.m.	27·82	,, 21	11.30 ,,	27·28
,, ,,	9.30 ,,	28·16	,, 22	9.0 ,,	26·30

The following levels were taken November 24th, 1894, in Stain Hill Park from marks left by the scum, &c. of the top water level:—

	ft.
Opposite Mr. Tatham's gate, "Homedale"	39·16
At No. 3 Kempton Park Villas, mark on glass in bay window ..	32·02

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Note on the Barometrical Changes preceding and accompanying the Heavy Rainfall of November 1894.

By FREDERICK J. BRODIE, F.R.Met.Soc.

[Received May 7th.—Read May 15th, 1895.]

A record of the disastrous floods which occurred over England in November last seems scarcely complete without some reference to the changes in barometrical pressure which preceded and accompanied the heavy rainfall. I have therefore drawn up a few brief notes on this subject, and have reproduced the Weather Maps for the close of the unsettled period, when the rainfall was heaviest and most general.

During September and the early part of October 1894, a drought prevailed over all the more western and northern parts of the United Kingdom, the greatest deficiency of rain being reported over the west of Scotland and the northern and central parts of Ireland. Applying the definitions commonly accepted for the driest portions of England (a practice that seems to admit of little defence in dealing with districts in which the average rainfall is two or three times as heavy), it appears that at several stations in the west of Scotland there was an *absolute* drought lasting for more than three weeks, while over a considerable portion of Ireland and Scotland there was a *partial* drought lasting from five to seven weeks. In isolated portions of the western and northern counties of England an absolute drought lasted for 15 or 16 days, while at Falmouth there was no rain between September 26th and October 18th—a period of 23 days.

After the middle of October, however, the weather underwent a complete change, and for the next four weeks the country was visited by a long succession of cyclonic disturbances, the centres of which travelled mostly in a north-easterly direction, either outside our western coasts, or directly ov the United Kingdom. During the first 10 or 12 days of the period the m important depressions observed were:—

(1.) A system of moderate intensity, which advanced from the Bay of B on October 19th, and which afterwards moved in an east-north-easterly dir across the south of England, and thence on to Denmark and the Baltic. I its progress, Easterly or North-easterly gales were experienced on many our north-east and north-west coasts, and Westerly gales in the English C with heavy rain over nearly the whole of Ireland and England.

(2.) A far deeper depression, with minimum readings below 28·7 centre of which travelled in a north-north-easterly direction across Ir Scotland on the 24th, and which afterwards passed on to Scand Northern Russia. The passage of this system was attended by s from various quarters on nearly all our coasts, with very heavy rai western districts, and, locally, at some of the southern stations.

(3.) A rather shallow depression, which spread eastwards over England on the 26th, but which gradually dispersed on the follo

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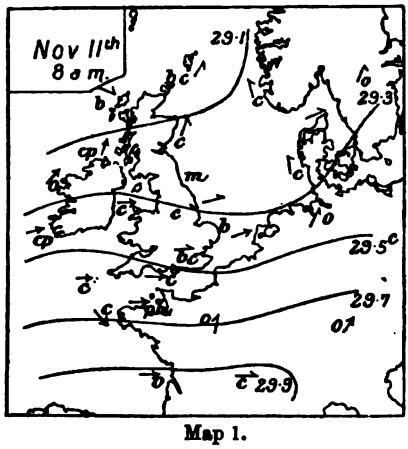
this case gales were felt at the Channel stations only, but heavy rain again fell in many of our western and southern districts.

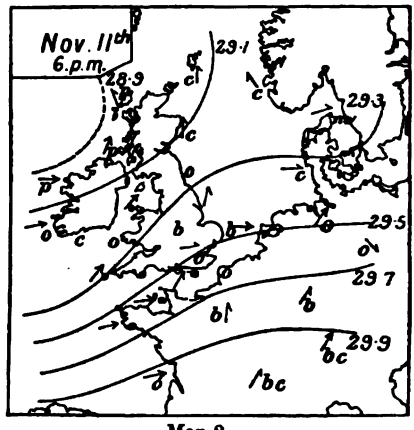
(4.) A series of small depressions,—subsidiary to a larger disturbance off our north and north-west coasts—which passed immediately over the kingdom on the 29th and 30th. These disturbances, though too shallow to produce much wind, were attended by further large quantities of rain over the southern parts of Ireland and England, the falls being in some cases excessively heavy.

Before dealing with what may be described as the crucial period in the history of the floods, viz. the four days commencing with November 11th, it will be readily gathered from the foregoing remarks that the latter half of October was characterised by unusually bad weather, especially in the more western and southern parts of the United Kingdom, where the rainfall was exceptionally large. The soil was, in fact, thoroughly saturated, and in the worst possible state for meeting the tremendous excess of rain which occurred after November 10th.

On the morning of the 11th (see Map 1), a depression was passing away in a north-easterly direction to the northward of our islands, the barometer was rising a little on our south-west coasts, and fine weather prevailed over a considerable portion of the United Kingdom. The wind was from the Westward or South-westward, and blew freshly or strongly in the west and south.



Map 1.



Map 2.

A black dot denotes that rain was falling in that locality at the hour of observation.

Map 2, for 6 p.m. of the 11th, shows that by that time a double set of changes was in progress. Off the west of Scotland there were decided indications of the advance of another large depression from the westward, while on our south-west coasts the downward trend of the isobar marked 29·8 ins., coupled with a brisk fall of the barometer at Scilly and a backing of the wind there from West to South-west, seemed to show that a secondary disturbance was approaching the more southern parts of the Kingdom. On our north and east coasts the weather remained fine, but in the western parts of the English Channel, as well as in the north-west of France, steady rain was falling.

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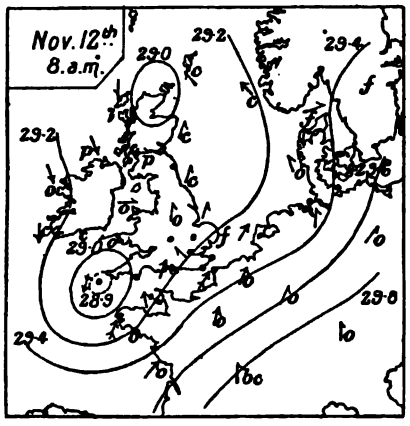
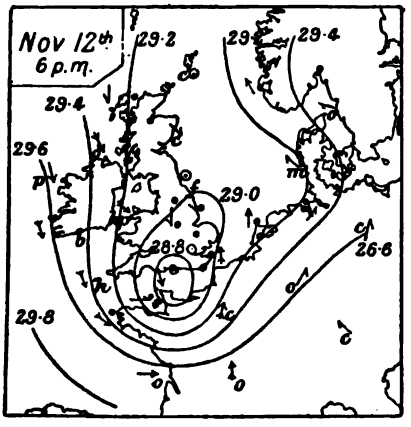
The chart for the following morning (Map 3) showed that in the course of the night the main disturbance had travelled north-eastwards, its centre being shown at 8 a.m. over Caithness. In the south a very decided change had occurred, and from an examination of the automatic records made at Valencia, Scilly and Falmouth (access to which has been kindly granted by the Meteorological Council), it is quite clear that a secondary depression of considerable depth had been rapidly formed slightly to the northward of the Scilly Islands. At Valencia the barometer fell very gradually, and the wind veered from South-west to North, while at Falmouth the mercury went down quickly after midnight, the changes in wind direction both there and at Scilly being sudden and very peculiar. By 8 a.m. on the 12th the centre of the secondary depression lay a little to the south-eastward of the Scilly Islands, the wind being strong to a gale from the



Map 3.



Map 4.

Southward or South-westward at the Channel Stations generally, but from the Northward at Scilly. Steady rain was now falling at nearly all stations in the south of England as well as in the north of France. Later in the day the main depression over the north of Scotland entirely dispersed, while the secondary in the south moved steadily eastwards along the Channel. By 2 p.m. the centre of the latter system lay about midway between Prawle Point and the Channel Islands (the minimum pressure occurring at Falmouth at 1 p.m.), while at 6 p.m. it was situated a little to the southward of the Isle of Wight (Map 4). In the south-west of England the weather now showed some improvement, but in all other parts of our southern districts rain continued to fall steadily, while in the course of the evening, when the centre of the disturbance travelled north-eastwards, lightning, thunder and hail were experienced over our south-eastern counties.

By 8 a.m. on the 13th (see Map 5) the depression had reached the Danish coasts, and the weather over England had become fine and bright, with moderate to fresh breezes from the westward. In the extreme west of our Islands, however, the isobars were again trending downwards, a decided fall

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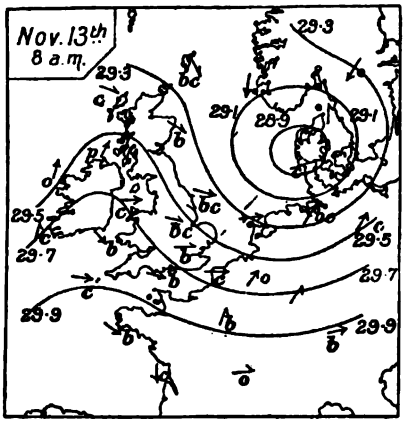
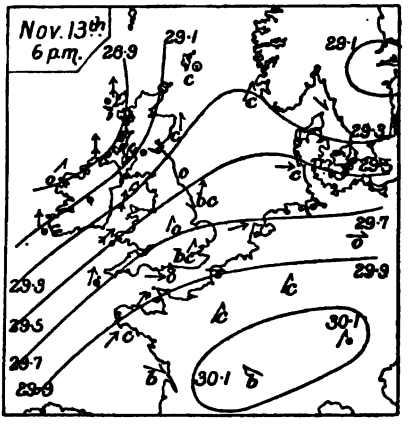
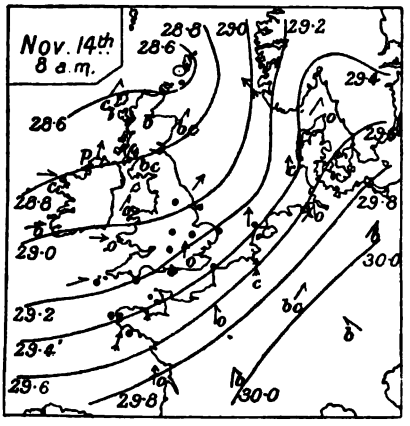
of the barometer being reported in the west of Ireland with a return of the wind to the Southward and with an increase of cloud. Later on the barometric fall became very rapid, and by 6 p.m. (Map 6) a large depression was seen to be approaching our north-west coast. Southerly and South-westerly gales and rain were now reported at nearly all our western stations.



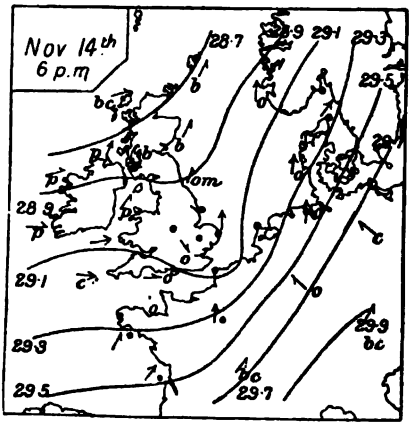
Map 5



Map 6.



Map 7.



Map 8.

The chart for next morning (Map 7) was somewhat similar to that for 6 p.m. of the 11th. In the course of the night the main depression had travelled north-eastward, and by 8 a.m. of the 14th it was passing away to the northward of Scotland. In the neighbourhood of the Bristol Channel, however, there were again some indications of the formation of a secondary disturbance, the compression of the isobars due to this small system resulting in further gales from the South and South-west over the Channel. Steady rain had now set in over nearly the whole of England, the weather in Ireland and Scotland being comparatively fine, though showery in places.

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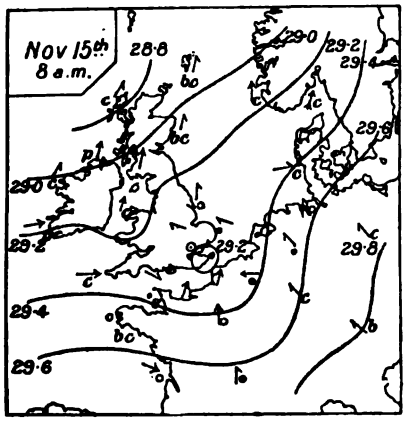
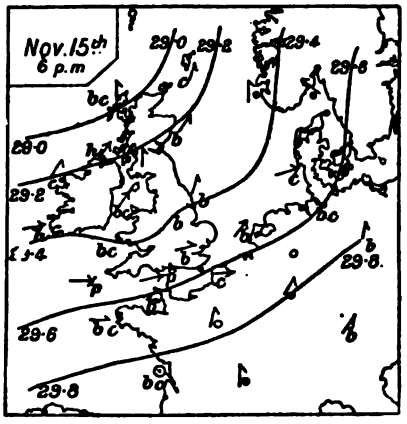
Later in the day the secondary disturbance underwent a gradual process of development (though not to anything like the same extent as in the case of the former disturbance), and moved steadily eastwards across the southern parts of England, its centre being shown at 6 p.m. (Map 8) over the south-eastern counties. During the afternoon a severe gale from the southward was experienced on the Kentish coast. In the course of the ensuing night the depression appears to have made very little progress, and at 8 a.m. on the 15th (Map 9) the centre remained over the south-east of England, steady rain being still reported at many of the eastern and southern stations. Later on, however, the system moved north-eastwards and dispersed: the weather in the south improved decidedly, and the period of heavy rainfall was practically at an end.



Map 9.



Map 10.

The conclusion of the whole matter seems to be that the torrential rains of November 11th-14th were caused by two secondary depressions, each of which developed a certain amount of intensity. In the case of the former the depression grew to such an extent as to entirely overshadow in importance its primary,—a feature not uncommon in the history of such systems. In the latter case the secondary never attained very much prominence, the cyclonic circulation round its centre being only partially developed. The formation or growth of a barometrical depression is ordinarily attended by heavy rains, and the wetness of the weather at this time was, therefore, by no means surprising. The barometrical changes seem to furnish, however, but a very inadequate explanation of the exceptional character of the rainfall, so that in this, as in many other cases, the meteorologist is forced to admit that there are factors in the weather of which at present very little is accurately known.

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A NATURAL THERMOMETER.

By Rev. FENWICK W. STOW, M.A., F.R.Met.Soc.

[Received March 27th.—Read May 15th, 1895.]

Most people will remember that the frosts of May 21st, 1894, and the two following days, were remarkably severe for the time of year; and did much damage to the foliage of forest trees, and to all fruit trees that were then in blossom.

A few days after the frost, I noticed that some large spreading horse-chestnut trees near the village of Thoralby, and close to the stream known as the Bishopdale Beck, presented a curious appearance. The foliage of the lower branches was quite blackened, but halfway up less injury was done; while at the top, in spite of the greater exposure to radiation, from which the lower boughs were comparatively sheltered, the leaves remained tolerably green. It would have been difficult to show by a photograph the contrast between the appearance of the higher and lower branches, as the leaves which were blackened by frost remained on the trees, and would have too much resembled those which were still green.

In the case of ash trees, however, a singular phenomenon presently showed itself, which I was able to photograph. Ash trees in this part of Wensleydale and Bishopdale, at an elevation of 500 to 800 feet, usually come into leaf at the beginning of June.

In the spring of 1894 they were unusually forward. On May 21st they were all in bud, and a few warm days would have covered them with leaf.

The effect of the frost on the higher ground was to retard their coming into leaf; but the buds were uninjured, and before the middle of June they were all in pretty full foliage. It was otherwise with those which stood in the wide and flat valley of Bishopdale, below Aysgarth Vicarage.

On June 27th a large ash tree in the very lowest part of this valley showed scarcely a single leaf, the buds having been quite destroyed. Crossing the valley by the road, which rises very slightly, I observed other ash trees which showed leaf at the top. Further on, the leaf extended half-way down the trees, and at last, on approaching the village of West Burton, on the opposite side of the valley, the ashes were clothed with foliage all over. Close by was the garden of Mr. J. C. Winn, where a minimum temperature of 23° had been registered in the May frosts in a screen of the Stevenson pattern—or rather, in the improved screen adopted by this Society. At the Vicarage, which stands between the main valley of the Yore and Bishopdale, and 180 feet above the latter valley, the minimum was 28°.

As the leaf buds had not been destroyed near Mr. Winn's garden, which is some 25 feet above the lowest part of the valley, it is evident that the temperature which destroyed the leaf buds must have been lower than 23°.

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There are many other ash trees in the valley, and, as far as I could see, all, according to their respective position, presented similar appearances. I did not see any tree but that one absolutely devoid of leaves. But there was only one near it, and that one was higher and therefore had leaves at the top.

It is scarcely necessary to observe that the local depression of temperature near the surface of the ground in a valley depends upon the dryness of the air. If the air is moist and the night mists or frost-haze have extended some distance up the hillsides, the minimum will not be very low, but nearly uniform, within the limits of the mist, owing to the obstruction to radiation caused by the mist, and to the setting free of latent heat by its formation. But if it is very dry, and the dew point excessively low, the local depression of temperature in the lowest part of the valley may be very great. I used to keep a minimum thermometer in an extemporised screen not far from this unfortunate ash tree, and in the winter of 1881 it registered −13°. The late Mr. Whipple kindly ascertained for me the error of the thermometer, which at 0° was 0°·9, so that the correct temperature was −12°, 9° lower than at the Vicarage. In the winter of 1879-80 Colonel Ward placed, at my request, a registering thermometer in a hollow place near the bottom of the valley at Rossinière, in Switzerland, where he then resided. He obtained the astonishing record of −37°, and for a week the average minimum of −25°. The record at his residence, only 100 feet higher, was −12°, showing a difference of 25°. But I do not think that the air is ever dry enough in the British Isles to admit of so great a local depression as this.

During the frosty period of May 1894 the air was dry, but not unusually so. I should have expected the local depression of temperature in the valley to be 6° or 8°: that is to say, the minimum to be from 22° to 20°. This agrees with the conclusion derived from the indication of Mr. Winn's thermometer, namely, that the temperature which destroyed the leaf buds was lower than 23°.

It would seem that the indications of the ash trees, turned into Fahrenheit's scale, recorded a temperature of about 20°.

I may add that in the severe frost in February of this year the air was not particularly dry. The frost-haze, as shown by the rime on the trees, extended at some time in the night of the 7th as far up as the Vicarage, where the lowest temperature was −2°·1. A little lower down, on the south side of the valley of the Yore, and a furlong from the Vicarage, −4°·2 was registered. Mr. Winn's thermometer registered −6°. The difference therefore was not great.

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HOURLY VARIATION OF SUNSHINE AT SEVEN STATIONS IN THE BRITISH ISLES.

By RICHARD H. CURTIS, F.R.Met.Soc.

(Plates 7-18.)

[Received February 16th.—Read June 19th, 1895.]

THE present is, I believe, the first attempt which has yet been made to deal with the subject of the hourly variation of the duration of sunshine over a considerable area of the British Isles, by means of hourly tabulations of the records. The short time which has elapsed since the introduction of the sunshine recorder, as part of the instrumental equipment of meteorological observatories, has made it impossible to deal with the subject earlier, and, indeed, it is not suggested that the period of 10 years which is now available is sufficiently long to yield other than approximate values; I believe, however, that it is long enough to enable one to obtain a fair idea of the character and extent of the hourly variations for the months and seasons, and it is in this tentative way that the following remarks are offered.

The data used will be found in the tables of mean results which are about to be issued by the Meteorological Office, as an appendix to the volume of *Hourly Means* for 1891, and I am indebted to the Meteorological Council for permission to use these tables before they are actually published.

The instrument used at each of the stations dealt with is Sir G. G. Stokes' modification of Mr. Campbell's original recorder, introduced in 1880, in which the sun's rays are focussed upon a strip of card, where they burn a trace representing the sun's path across the heavens. The record obtained is therefore one of *bright sunshine* as indicated by the intensity of the solar *heat* rays, and it affords no measure of the sun-*light*, or of the *actinic* rays, as apart from those of heat.

Unless the heat rays have, when focussed upon the card, sufficient power at least to discolour it, no record at all is made, and this point is therefore the inferior limit at which the instrument will register; on the other hand, when insolation is strong, and the solar rays are unobstructed, a clear burn of greater or less width is made right through the card, and therefore between these limits the instrument affords a rough scale of the intensity of the sun's heating power. In tabulating the records, however, no attempt was made to take *intensity* into account; any visible trace, however faint, was measured, and the measurements combined without distinction with those obtained from stronger records.

Until the sun has reached a certain altitude above the horizon its rays have not sufficient power to affect the card, and thus no trace is ever made within the 15 minutes immediately following sunrise or preceding sunset. A slight film of cirrus haze also, or even a slight haziness of the lower atmos-

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phere, although it may not prevent the sun from shining with sufficient brightness to cause faint shadows to be cast, will yet frequently suffice to intercept enough of the heat rays to stop the record. The low ground mists, more commonly experienced at sunrise than at sunset, have the same effect; but the amount of trace lost through them will obviously depend in

Campbell-Stokes Sunshine Recorder.

some degree upon the position occupied by the recorder, which if placed near the ground, as at Stonyhurst, may be expected to lose more from this cause than if it be placed high above the ground-level, as at Aberdeen; the character of the surrounding district is also a factor of much importance in this connection.

The following particulars as to the exposure and position of the instruments at the observatories now dealt with ought to be given; the stations are arranged according to latitude.

ABERDEEN.—The instrument is placed upon the Cromwell Tower of Aberdeen University, at a height of 75 feet above the ground, where it has a good exposure at all seasons of the year. To the eastward the sea is not far off, whilst the city of Aberdeen is about a mile distant to the south. To the west and north the ground rises, with hills in the distance.

GLASGOW.—The Observatory is in a western suburb of Glasgow, the neighbourhood of which city must necessarily affect the amount of sunshine recorded. The instrument is 24 feet above the ground, and has an unobstructed horizon for sunshine at all seasons of the year.

ARMAGH.—The height of the instrument above the ground is 38 feet, and its horizon is perfectly free from obstruction, except for a few minutes at about 4 p.m. during April and August, and to a less extent during May and September also. The Observatory is situated on the top of a hill, a quarter of a mile to the north-eastward of the city, and about 100 feet above the general level of the surrounding country, the character of which is pastoral and well wooded.

STONYHURST.—The recorder is only 4 feet above the ground, and the sun's rays are cut off from it by buildings for a very short time at sunrise in spring, and at sunset in midwinter. The exposure is otherwise good, and the surrounding country, although hilly, is very open.

VALENCIA.—Throughout the ten years the recorder was at the old Observatory, it was fixed 7 feet above the ground, but its exposure for sunshine was good throughout the year. The Observatory was quite close to the shore, and although the surrounding country is hilly, it is not wooded, and the hills are too remote to interfere with the record.

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KEW.—The instrument is placed 47 feet above the ground, on the parapet of the Observatory, which stands in the Old Deer Park to the north-west of the town of Richmond, and about three-quarters of a mile from it. The River Thames is less than a quarter of a mile away to the west, while to the north and east the level ground of the park extends for a considerable distance. There are no buildings near the Observatory in any direction, but it is possible that a few minutes of early and late sunshine may be cut off from the recorder in mid-winter by isolated trees.

FALMOUTH.—The instrument has occupied two positions during the ten years. Until 1885 its height above the ground was 50 feet, but in that year the Observatory was removed to a new site, and the height of the instrument was changed to 84 feet. In both cases the exposure for sunshine was a perfect one, the observatories standing on high ground nearly 200 feet above the mean sea level, and quite above the chief part of the town of Falmouth. The surrounding country is hilly and slightly wooded, whilst to the southward the open sea is only about a mile distant.

Obviously, with so limited a number of stations as seven, scattered over an area comprising 7° of latitude and 10° of longitude, it would be useless to attempt to draw any conclusions as to the general distribution of sunshine over the British Isles. The following observations on the tables are therefore offered without pretending to regard the respective stations as representing more than the districts immediately surrounding each.

There are two ways in which the records may be considered. Either the number of hours of sunshine actually observed may be dealt with, in which case, when comparing the records of different stations with each other, it becomes important to bear in mind the varying lengths of time that the sun is above the horizon of each place, and which is, of course, dependent upon the latitude of the station and the season of the year; or the observed amount of sunshine at a station may be considered with reference to the amount which would have been received there, supposing the sun to have shone without obstruction during the whole time it was above the horizon, and that its whole duration was recorded. In the latter case the *observed* amount would be expressed as a percentage of the *possible* amount. Both these methods have advantages of their own, and therefore the results in the tables are expressed in both ways, wherever possible.

Turning to the figures, it is of interest to notice that upon the whole there is a fairly close agreement between the means for the two five-year periods into which they are grouped. From this fact it may be inferred that the ten-year means, with which alone it is now proposed to deal, approximate with a fair degree of closeness to the means which a longer period would have yielded had the figures been available.

Taking first the average daily duration for the whole year, we find that Falmouth is decidedly the most sunny station of the seven, having a daily average amount of sunshine of just over 4½ hours. This amount is half-an-hour more than that recorded at Valencia, the station with the next highest average, and three-quarters of an hour more than Kew, which holds the third place. Of the remaining four stations, Aberdeen, the most northern, but at the same time a coast, station, with 3·64 hours, has more than either Stonyhurst or Armagh, both inland stations; whilst Glasgow, with only 3 hours per diem, or about a quarter of its possible amount, has the smallest

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record of the seven, a result to some extent due, without doubt, to the nearness of the Observatory to some of the large manufacturing works with which the city of Glasgow abounds.

Or, if we deal with these figures, as representing percentages of the possible duration at the respective stations, we find that the order in which they succeed each other as regards their comparative sunniness is unchanged. The 4½ hours at Falmouth represent 37½ per cent. of the possible amount, while the 3 hours per diem at Glasgow represent but 25 per cent. of the possible amount for that place.

If we group the months so as to represent the four seasons of the year, taking December to February inclusive as winter, March to May as spring, June to August as summer, and September to November as autumn, it will be found that during the winter quarter the south-western stations again appear as the most sunny of the seven. Falmouth and Valencia have in this three months each an average daily amount of 2 hours, while Aberdeen, notwithstanding its high latitude, occupies the third place with a mean duration of rather less than 1¾ hours per diem. Armagh, however, with just over 1½ hours per diem, has during this quarter decidedly more sunshine than the remaining three stations, both Stonyhurst and Kew having about a quarter-of-an-hour per diem less, whilst Glasgow has the smallest daily average of just under one hour.

In the spring quarter, with the increase of the sun's declination, a great increase in the average daily amount is, of course, noticeable, but the relative positions of the stations as regards the length of their daily average is not much changed. The two south-western stations have again the longest duration, but Falmouth, with nearly 5·7 hours, has begun to take the lead, although the duration is only one-tenth of an hour per diem more than that at Valencia. Kew, notwithstanding its proximity to London, which might have been expected to militate against its record of sunshine, now comes next to Valencia, although its mean daily amount is three-quarters of an hour less. Aberdeen, Stonyhurst and Armagh follow in the order named, the mean duration at Aberdeen being 4·66 hours and at Armagh 4·53 hours, and Glasgow is again lowest with an average duration of only 4·12 hours per diem.

In the summer quarter Falmouth and Kew both show an increase in the mean daily duration of more than an hour and a quarter, and whilst Falmouth, with a mean daily duration of 7 hours, is still the most sunny place, Kew comes next to it with a mean of 6·1 hours. Valencia shows only the trifling increase of a tenth of an hour upon its average for the spring months, and is the third upon the list; whilst Aberdeen and Stonyhurst are not far below it, with nearly 5½ hours each. The increase in the duration at Glasgow from the spring quarter is nearly three quarters of an hour, whilst the increase at Armagh is barely two-tenths of an hour, and as a consequence the former station shows a higher record than the latter, the 4·72 hours duration at Armagh being the smallest recorded at any of the seven stations. It is a peculiar fact of some significance, that the increase in the daily duration

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shown by the two Irish stations from spring to summer should be so small, whilst it is so decided at each of the other five.

In the autumn three months the relative distribution of the daily duration reverts again to very nearly that of the spring, but the average amounts are in every case much smaller, owing to the shorter length of the mean day. Falmouth has an average of 3·64 hours sunshine per diem, which is more than half an hour above the duration at Valencia and Kew, the figures for which two stations are now almost identical. The mean duration at Aberdeen is 2¼ hours, and Stonyhurst and Armagh have both of them a tenth of an hour less, the difference between the autumn and summer duration being less at the latter station than at any other. Glasgow, with only 2·1 hours per diem, again falls into its usual position with the smallest average amount of any station in the series, an amount which is only a tenth of an hour above the average duration at Falmouth and Valencia during the winter quarter.

Turning now to the daily means for the several months, we find, as might have been expected, that January and December are the most sunless months of the year. At no station is there much difference between them, but the smallest mean daily duration of sunshine occurs in December at every station except Falmouth, where January is the less sunny month of the two. In January the mean daily duration varies from seven-tenths of an hour at Glasgow to rather more than 1·8 hours at Valencia; Stonyhurst has one hour, and the daily amounts at the remaining four stations—Kew, Armagh, Falmouth, and Aberdeen—show a progressive increase, in the order named, of between one and two tenths of an hour. After January the mean daily duration increases quickly except at Kew, where the increase shown in February is only slight, and is less than that of any other place. In March, however, this defect is made up, and from thence to May the mean daily amount continues to increase each month with fair regularity at all the stations; Valencia and Falmouth keep very close together, with daily amounts considerably greater than those of any other station; Aberdeen, Armagh, Kew, and Stonyhurst are also very similar, whilst Glasgow has uniformly the least amount of all.

At Valencia, Kew, Stonyhurst, and Armagh, the maximum duration is reached in May, the daily mean amount varying in the order named from 6¾ hours to 6 hours. At Falmouth and at the Scotch stations the increase is maintained, although in a less degree, until June, when the mean duration at Falmouth reaches 7¼ hours, at Aberdeen 6¼ hours, and at Glasgow 5·6 hours. From May to June the decrease shown at those stations which attain their maximum in the earlier month is not great, but from June to July the decrease is not only general, but at every place, except Kew, very large. At the Irish observatories it is about 1¼ hours, at the Scotch one hour, and at Falmouth and Stonyhurst about three-quarters of an hour; at Kew it is but a tenth of an hour, and this place is peculiar for the very gradual decrease shown through the three summer months—June to August. At most of the stations, however, this rapid decrease is not maintained. At Falmouth the

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duration in August is but a tenth of an hour less than in July, and at Valencia it is actually a tenth more, whilst at Glasgow and Aberdeen the decrease from July to August is less than half an hour; at Armagh also the rate of decrease slackens, and continues to do so until September, but at Stonyhurst there is no check in the rate after June.

From August to the end of the year the rate at which the mean daily duration decreases, although rapid, is less so than was the increase during the first five months of the year. At the English and Scotch stations the diminution is fairly uniform, and at Falmouth and Kew remarkably so, Kew having throughout rather more than half an hour per diem less sunshine than Falmouth. The Irish stations are peculiar in having a more gradual rate of decrease, and especially is this the case at Armagh. As a result, although in August the mean daily duration at Armagh is less than 4 hours, which is nearly half an hour less than that of Glasgow, in November it is still nearly 2 hours, and exceeds Glasgow by an hour. The fact that in July and August the mean duration at Armagh is less than that at any other station, not excepting Glasgow, is one of some significance.

It will now be interesting to consider these same figures when expressed as percentages of the possible duration at the respective observatories, because their meaning then becomes to some extent modified by the season and latitude of the station. Judged in this way, by what may be termed their capabilities, we find that in January Aberdeen and Valencia, the most northern and most western stations, are practically alike, with 22 per cent. of sunshine; Falmouth and Armagh, although two very dissimilar stations as regards their physical surroundings, have each about 18 per cent.; Kew and Stonyhurst, both inland stations, each get about 18 per cent.; whilst Glasgow, with only 9 per cent., is the least favoured station of the seven.

The values for the subsequent months follow in a general way the course of the mean hourly amounts already referred to, but they present more sharply some features which were made less apparent by those figures.

Taking first the values for Falmouth, which are generally higher than those for any other place, the monthly increase in the percentages is uniformly about 8 up to April, then only 8½ in May, and less than 1 in June. In July the percentage falls from 46 to 43, but it rises again in August to nearly 47, which is a trifle above that of June, and is the maximum of the year. Thence it decreases less rapidly than it increased in the spring to 21½ in December. The most noticeable point here is that the slight diminution shown in the mean hourly duration between July and August becomes a decided increase, when it is expressed as a percentage of the possible amount, and exhibits in a striking manner a summer minimum and second maximum. Comparing these values with those for Valencia, the station which most nearly resembles Falmouth in its surroundings, we notice that after January there is an almost perfect similarity between them up to April, when they begin to diverge greatly from each other. The maximum, 43 per cent., is reached in May, and is followed by a decrease to 32 in July;

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in August there is a rise of 4 per cent. to a second maximum, and then again a fall to the close of the year; but it is remarkable that in September and October the decrease is only slight, and this with the sharp decrease in June and July are the two principal points of difference between the values for the two stations.

The values for Kew, Stonyhurst, and Armagh, three inland stations, are not very dissimilar during the first five months of the year, the principal differences being that Stonyhurst in February shows a greater increase in its percentage than the other two, and that at Kew the increase in March is very large; but at each place the maximum is attained in May, after which the march of the phenomenon at the three stations becomes altogether dissimilar. At Kew the percentage decreases from the maximum of 41½ in May to a summer minimum of 38 in June, after which it increases to a second maximum of 41 in August; then follows a steady decrease to 14½ in December. At Stonyhurst the maximum of 39 in May is succeeded by a steady decrease to 33 in July, and less abruptly to 31 in September, after which it falls quickly again to 12 in December; but although the decrease of the percentage is retarded in August, there is no rise to a second maximum, and in this respect Stonyhurst is alone. At Armagh the maximum is 37½ per cent. in May, and this is followed by a drop similar in amount to that at Valencia, which brings it to 27 in July, the fall at the two Irish stations being greater than is shown at any other place. In August, however, there is a further slight fall instead of a rise, and the second maximum does not occur until September, after which there is a decrease of about 5 per cent. by November, which is far less than elsewhere, followed by a rapid decrease to 15½ per cent. in December. The two Scotch stations have also their maximum in May—36½ at Aberdeen, and 33 at Glasgow—with a summer minimum in July and a second maximum in August; then at Aberdeen, as at Valencia, the decrease in the percentage is slight until October, after which it falls away rapidly, whilst at Glasgow the decrease is more rapid and uniform from August to the close of the year.

We come now to the distribution of sunshine throughout the day as exhibited by the mean hourly amounts, and the figures will probably be best dealt with if each observatory is taken separately. It is, however, necessary to bear in mind here that the comparative shortness of the period over which the observations extend is more likely to make itself felt detrimentally when the figures are broken up into such small divisions as hours, than when they are grouped to represent the daily amounts for the months and seasons, which have already been dealt with, and any conclusions drawn can therefore only be regarded as more or less provisional in character.

The most prominent feature brought out at all the stations is the rapid increase in the mean hourly amount of sunshine recorded during the first few hours following sunrise, and the even more rapid falling off again just before sunset. Speaking broadly, this rapid increase in every month of the year seems to cover about two to three hours, and the decrease rather less, the changes in the hourly amounts during the remainder of the day being of

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much smaller amplitude. Bearing in mind that the record is one of sun heat, it would seem that the infrequency of sunshine at these relatively early and late hours is not so much owing to greater cloudiness as to the fact that insolation is cut off by the greater extent of the lower atmosphere through which the solar rays have to pass, and which just after sunrise and before sunset is more charged with condensed vapour than is the case during the intervening hours of the day.

Taking first the most northern station, *Aberdeen*, the values for the different months show a great similarity in the daily march of the phenomenon (Plate 7). The most sunny hour is always at, or very close to, noon, and after the early hours there is no indication of any part of the day being especially favoured as regards sunshine. In the winter the increase in the mean amount goes on steadily to the maximum, and at once falls off again as regularly; but in the spring and summer months the maximum amount is maintained over a longer period, and there is but little difference between the mean amounts for some hours before and after the time of actual maximum. April and June are exceptions to this rule, to the extent that the later hours of the day are decidedly more sunny than the corresponding hours in the morning; but this is not the case in any marked degree in any other month. Taking the means for the whole year, the maximum frequency occurs at noon, and the hours following noon have a slight advantage over those preceding it. The average amount of sunshine per hour in the sunniest part of the day varies from about three-tenths of an hour in winter to very nearly half an hour in May; in June and August it also approaches 50 per cent., but in March, April, July and September it is only about four-tenths of an hour. For the whole year the average amount of sunshine in the 60 minutes, from 11.30 a.m. to 0.30 p.m., is 0·39 hour.

The next station in order of latitude is *Glasgow*, the results for which place are very different from those yielded by Aberdeen (Plate 8). In the winter months the hourly increase is more gradual, and the maximum, though not so large as at Aberdeen, is reached less abruptly. The afternoon hours are also, as a rule, decidedly more sunny than those of the morning, and except in the winter the sunniest period is generally about 2 p.m. March and April, however, offer marked exceptions to this rule, as the maximum hourly amount occurs then at 11 a.m. and noon respectively, after which time the sunshine decreases steadily till 3 or 4 p.m., and then more rapidly to sunset. The values for the months May to September show a marked contrast in the very gradual increase hour by hour up to the maximum, and the rapid decrease after the maximum had been passed. Taking the mean hourly amounts for the year, the greater frequency of sunshine in the afternoon is well shown. The mean amount of sunshine per hour in the most sunny part of the day is less than two-tenths of an hour in November December and January; in February, March and October it amounts to about three-tenths of an hour; in July, August and September to rather under four-tenths of an hour; and in April, May and June to between four and a half and five-tenths of an hour; for the whole year it slightly exceeds three-tenths of an hour.

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At *Armagh* the hourly variation is in some respects peculiar during several months of the year (Plate 9). In January, February, and March the hourly duration increases rather quickly to a maximum just before noon, after which it falls off again more gradually than it rose. March has a less rapid increase, and exhibits a decided minimum at 2 p.m., rising again at 3 p.m., and then decreasing till sunset. In April, May, and June the hourly increase is rapid and is not followed by any very decided maximum, the amount of sunshine experienced showing but very slight variation till within a few hours of sunset, when the decrease is as rapid as was the morning increase. In July the maximum occurs as early as 9 a.m., after which it falls away to noon, which is a less sunny hour than 7 a.m. From noon to 5 p.m. the average amount of sunshine does not vary much, and it then decreases quickly to the hour of sunset. In August both the increase and decrease are more gradual, and the maximum does not occur till 1 p.m., and the remaining months of the year exhibit an hourly variation not very dissimilar to that of the corresponding months at the beginning of the year, the only prominent feature being a secondary minimum in October at 1 p.m. The maximum amount per hour varies from about a quarter of an hour in January and December to rather less than half an hour in May, and it is only in April, May, and June that it ever exceeds four-tenths of an hour. In July, for the greater part of the day the amount per hour is only equal to that found in February and November. Dealing with the whole year, the sunniest part of the day occurs just before noon, and the average amount of sunshine is three-and-a-half-tenths of an hour.

Stonyhurst is the station next in order of latitude, and it is also, like Armagh, an inland station (Plate 10). In the first two and last four months of the year the distribution of sunshine throughout the day follows a fairly even course, the maximum occurring in each case at about noon, and being preceded and followed by a pretty uniform increase and decrease in the hourly amounts. In March and April, however, the most sunny hour is 11 a.m., the hourly amount increasing quickly up to that hour and then falling off steadily till the evening. In May and June 1 p.m. is the sunniest hour, with 4 per cent. more of the possible amount of sun than noon, the falling off in the latter month being very gradual until after 4 p.m., while the increase in the morning hours is less rapid than in May. In July and August this retardation of the morning increase is still more marked than in June, and the maximum does not occur until 2 p.m., after which, in July, it is maintained till 4 p.m. before it begins to fall quickly, whilst in August the falling off begins at once, and 3 p.m. has 5 per cent. less sun than 2 p.m. The maximum hourly duration varies from two-tenths of an hour in January and December to five and a half-tenths of an hour in May. February has a tenth of an hour more sun at noon than has January and the March maximum shows a similar increase upon February. From April to September, with the exception of May, the maximum hourly amount is from four and a half to five-tenths of an hour; October is a tenth of an hour below September, and November, with two and a half-tenths, is a tenth less

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than October. For the year the maximum hourly duration is less than four-tenths of an hour, and occurs at noon and 1 p.m.

Valencia, the next station south, is one of the most sunny of the seven (Plate 11). In the winter months of November, December, and January the maximum hourly duration occurs at 11 a.m., and a rapid increase throughout the morning hours is followed by a much more gradual falling off during the afternoon; in February, however, this latter feature is less pronounced, and a more uniform increase and decrease is exhibited throughout the day. In March it again becomes very marked, and the maximum at 11 a.m. is followed by a very steady but marked diminution till 4 p.m., and then by a rapid fall to sunset. It is worthy of note that in a less degree this is a feature of the diurnal variation in March at all the stations, with perhaps the exception of Aberdeen and Falmouth. In April little difference is shown in the hourly amounts from 9 a.m. to 1 p.m.; but in May and June the hourly duration goes on increasing till 1 p.m. before the maximum is reached, the hours following noon being much more favoured as regards sunshine than the corresponding hours before noon. In July the chief feature is the very gradual increase in sunniness from 6 a.m. to noon; but the three following months exhibit upon the whole a fairly uniform increase and decrease, with but little change during the middle hours of the day. The winter months show high maximum hourly durations:—In December it is nearly three-tenths of an hour, and in November, January and February from three-and-a-quarter to three-and-a-half-tenths. March has half an hour, and the three following months about half-a-tenth more, but July, August and September reach only about four-and-a-half-tenths as the maximum, and October rather less. For the whole year the maximum hourly duration is about four-and-a-quarter-tenths of the total possible, and the diurnal variation follows a fairly uniform course from sunrise to sunset, the maximum occurring at noon.

Kew is only about half a degree south of Valencia, but being an inland station it exhibits some strong contrasts to the latter (Plate 12). The chief of these are the relatively small amount of insolation in winter, and the more uniform diurnal distribution exhibited in most months of the year. In January, February, November, and December the maximum occurs at noon or 1 p.m., but in January, and still more in February, the steady hourly increase is somewhat checked in the morning at about 11 a.m. In March the maximum amounts to about 15 per cent. more than in February, and occurs at 11 a.m., and is followed by a slow but decided falling off till 8 p.m., after which hour the decrease becomes rapid till sunset. In April, 10 a.m., with 47 per cent. of the possible amount, is the sunniest hour, the average duration in the succeeding hours being fairly uniform, but decidedly less than at 10 a.m. May exhibits a very uniform variation in the diurnal distribution, with the exception of a slight check at 9 and 10 a.m., the maximum at 11 a.m. being followed by a slight but steady falling off till 4 p.m. In June, however, the maximum does not occur till 1 p.m., and the diurnal variation is again fairly steady. July exhibits a remarkable falling off in the mean amount recorded

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during the afternoon hours, more especially after 1 p.m., and the hour of 8 p.m. is less sunny than it is in either of the two preceding or succeeding months. In August and September there is a fairly uniform increase and decrease shown, but in October the increase in the daily amount goes on steadily to the maximum at 1 p.m., after which the average amounts fall away very abruptly to sunset. From May to September inclusive the maximum hourly amount is about one-half of the possible amount. For the whole year the increase and decrease in the mean hourly duration is very uniform and steady, rising to 40 per cent. of the possible amount at noon and 1 p.m., and showing slightly higher percentages in the afternoon than in the corresponding morning hours.

Falmouth is both the most southerly and the most sunny of the seven stations, and in some respects its diurnal distribution of sunshine is different from that of any of the others (Plate 13); with hardly an exception its maximum hourly amounts are larger, and as compared with Valencia, the station to which it most nearly corresponds as regards its geographical situation and physical surroundings, it exhibits a more uniform diurnal variation, the maxima being in most months of the year deferred till much later in the day, while there is an entire absence of the marked decrease of sunshine in the afternoon hours which is so striking a feature of Valencia in some months. The least sunny month is January, when the maximum hourly amount is but a quarter of an hour at noon, the amounts recorded for 10 a.m. to 2 p.m. being but slightly less. In February the maximum hourly amount increases to nearly four-tenths of an hour at 11 a.m., and again there is but little falling off till 2 p.m. In March there is a marked slackening of the hourly increase at 9 a.m. and 10 a.m., but this is followed by a quick rise to the maximum at noon; it is noteworthy, however, that the maximum, which is less than half-an-hour, is considerably below that of Valencia for the same month, and also that there is no indication of the rapid falling off in the hourly amounts during the hours immediately succeeding which is shown by the Valencia means. In April the maximum increases to nearly five-and-a-half-tenths of an hour, and the p.m. hours are shown to be decidedly more sunny than the a.m. In May the hourly amounts increase steadily till 2 p.m., and do not begin to fall off much until after 4 p.m., the maximum being nearly six-tenths of an hour. In June the march of the mean hourly amounts is very similar to that shown in May, but the maximum occurs still later in the day, at 4 p.m., and slightly exceeds six-tenths of an hour. July is a decidedly less sunny month than either May or June, and a marked check in the increase of insolation is shown during the middle hours of the day; the maximum, which occurs at 8 p.m., amounts to only five-and-a-half-tenths of an hour. August is again a very sunny month, the maximum, which occurs at 2 p.m., equalling that of June, but it is ollowed by a more rapid falling off in the amounts during the two or three hours immediately succeeding. September brings a large decrease in the amount of sunshine; the maximum occurs at 1 p.m. and only slightly exceeds half-an-hour, there is, however, not much variation in the amounts

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recorded from 9 a.m. to 4 p.m. In October the maximum occurs as early as 10 a.m., after which the hourly amounts fall away slightly till 2 p.m., and then more rapidly to sunset. November and December both exhibit a very uniform increase and decrease in the mean hourly amounts, and in both cases the maximum is reached at noon. Taking the means for the year, the hourly march of insolation is very uniform; the maximum is reached at 11 a.m., and is maintained till 2 p.m., the afternoon hours having rather more sun than the corresponding hours of the morning. The maximum amounts to four-and-a-half-tenths of an hour.

DISCUSSION.

Mr. C. HARDING said that this paper dealt most completely with sunshine statistics, the data being discussed in regard to the monthly, seasonal and hourly variation, and the results possessing additional interest as the first of the kind ever published. Concerning the rise in the p.m. portion of the mean daily curve of sunshine at Glasgow as compared with the portion before noon, he thought that possibly the drift of the smoke from the various factories which abounded in that city was to some extent the cause of the difference between the morning and afternoon sunshine. It was comforting to note that Kew, in spite of its proximity to our smoky metropolis, came out with such good results.

Mr. H. S. WALLIS said that it would be interesting to see how far the discussion of sunshine observations at additional stations would modify or confirm the results shown in this paper. The increase in the amount of sunshine during the afternoon hours at Glasgow appeared, as Mr. Harding had suggested, to be due to the situation of the Observatory in relation to the manufactories, the Observatory being to the west, and the manufacturing district in the east of the city; so that during the morning hours the smoke cloud would be between the sun and the recorder, while in the afternoon the sun would be shining from the westward, and no smoke would intervene. These artificial conditions, and also the case at Armagh, where the shadow of the anemometer shaft caused an interruption in the record, suggested that too great a hurry should not be evinced in accepting the anomalies in the results given in this paper as representing physical facts.

Mr. F. C. BAYARD inquired whether any explanation could be offered which would account for the general flatness of the diurnal curves at all the stations between 10 a.m. and 3 p.m. He suggested that a description of both the Campbell-Stokes pattern of sunshine recorder and what was known as the "universal" recorder should be added to the paper. A difficulty often experienced with the "universal" pattern was that the ball was liable to slightly shift from a rigid position through the clamps with which it was held becoming loosened, the instrument thus being put out of focus. He had heard, too, that during heavy gales the ball of the Stokes' pattern had been blown off its pedestal at places where the recorder was in an exposed position.

Mr. W. H. DINES thought that Mr. Curtis had partly explained why the curve was almost flat in the middle of the day, when he stated that the instrument recorded sun heat rather than sun light. During the middle of the day, when the sun was high, no doubt a trace was made whenever the sun was shining; but in the two or three hours after sunrise and preceding sunset there was but little heat to spare; and an accidental occurrence, such as the paper being wet, or a strong wind tending to keep the paper cool, would stop the registration. He thought that in the summer the early morning and late evening were more cloudless than the middle of the day, and it would be very interesting if anyone present could enlighten them as to the behaviour of the photographic recorder in that respect. He had lately been trying a new form of sunshine recorder, which registered electrically on a clock drum. He found that if he adjusted this instrument so that it recorded the early morning and late evening sunshine, it also recorded in the summer during the day, when the sun was only just visible through clouds; but if it were adjusted so that it would record sun-

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shine at midday only when the sun was shining clearly, then it failed to record within an hour or half-hour of sunrise or sunset.

Mr. W. B. TRIPP said that of the two forms of sunshine recorders at present in use, one gave indications of the heat rays, and the other of the chemical rays of sunshine; a third instrument to record the rays of light appeared to be desirable.

Mr. G. J. SYMONS said that he knew very little concerning sunshine recorders; but, so far as he was aware, no attempt had yet been made to record the light or yellow rays of the solar spectrum, the red rays being of course registered by the burning recorders and the violet rays by the photographic recorders. He thought it was a matter for congratulation that the first elaborate discussion of sunshine observations should have been read before the Society, and it was something to be proud of to know that England possessed the most splendid organisation of sunshine observations to be found anywhere. It was of course perfectly clear that when the observations extended over 20 years instead of 10, many of the irregularities at present noticeable in the curves would disappear. As regards the increase in the afternoon sunshine at Glasgow, he was disposed to agree with the explanation suggested by Mr. Harding and Mr. Wallis; but the curve for Falmouth exhibited a very similar excess, which certainly could not be so easily explained away, as there was no accumulation of smoke at the Cornish town as there was in the Scottish city. The flatness of the curve during the middle of the day, to which attention had been drawn, was doubtless due, as Mr. Dines had pointed out, to the greater power of burning which the sun's rays possessed during the midday hours. He had always thought that the records of those now old fashioned instruments, solar radiation thermometers, were really dependent upon the sun's altitude, and the sunshine records appeared to be in a somewhat similar position. He had been wondering whether it would be possible to reduce all the sunshine observations to a hypothetical sun altitude.

The Hon. F. A. R. RUSSELL ventured to add the suggestion that this inquiry might with advantage be extended so as to include the relation of sunshine to the different winds in each locality. The results of such an investigation might be to afford, especially for certain hours of the day, some idea of the absorption of the sun's heat by the atmosphere under various conditions of wind.

Mr. T. W. BACKHOUSE remarked that the results of the paper seemed to show the effect of mist and haze on the registration of sunshine. He inquired whether the amount of cloud exhibited corresponding diurnal variations to those shown in the curves of sunshine.

Mr. F. GASTER said that many of the irregularities exhibited in the sunshine curves were without doubt due to lack of sufficient data upon which to base an average, the curve for the year being calculated from a considerable number of observations presenting a much smoother appearance than those for the individual months. Some interesting facts had been brought out as a result of investigation into sunshine records in the British Islands, and it was now known that coast stations, especially in the south, were sunnier than inland stations, and that the winter sunshine along the south coast was in excess of that recorded in other districts. The exposure of a station was an important factor in the comparison of sunshine observations, as it would be obviously unfair to compare the records from an instrument situated in a valley with those from one on a hill. In connection with the effect of smoke upon the recording of sunshine, it is not sufficient to consider whether an Observatory lies near a city, but the direction of the prevailing wind must also be taken into account. Kew and Greenwich, which are respectively situated west and east of London, are good examples of the effect of the wind upon the drift of the smoke, a Westerly wind carrying the smoke towards Greenwich, and so lessening the amount of sunshine recorded, while an Easterly wind exercises the same effect upon the Kew sunshine records. The flattening of the diurnal curve of sunshine in the middle of the day appeared to be due to the greater amount of cloud which it was well known prevailed during those hours.

Mr. W. MARRIOTT said that Mr. Ellis and the late Mr. Whipple had each communicated papers to the Society on the diurnal variation of sunshine at Greenwich and Kew respectively, but Mr. Curtis's paper was the first attempt to similarly discuss the sunshine records at several stations distributed over the British Isles. It would be interesting if the investigation could be carried still

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further, and some person with a large staff and plenty of funds at his disposal, or such individual observers who might feel so disposed, would discuss the hourly sunshine records in relation to direction and force of wind, temperature, pressure, and humidity, particularly the last named, as atmospheric moisture appeared to exert considerable influence upon sunshine records. When inspecting the Society's stations, he had frequently found the sunshine recorders to be imperfectly adjusted, the "universal" pattern being particularly liable to derangement owing to the glass sphere slipping out of position, the screw clamps which hold it in its place being liable to become loose. A ready method of testing the position of the glass ball was to pass a sovereign between it and the metal frame in which the card was placed; if the coin went round quite evenly the ball would be in the centre of the frame and in good focus. It would be interesting to have a comparison of sunshine records upon a hill and in a dale. Great difficulty was often experienced in securing a perfectly free horizon for a sunshine recorder, and the height of the instrument above the ground varied considerably at different stations. Some recorders were placed on the top of towers or lofty buildings, while others were exposed only a few feet above the ground, where the records were liable to be influenced by morning and evening mists. The physical features of a district required to be taken into account when comparing sunshine records. For instance, Ventnor, owing to its sheltered situation under the undercliff, which rose to a considerable height to the north-west, had the evening sunshine considerably diminished, and it would not, therefore, be comparable with, say, the records for Eastbourne, where the instrument had an uninterrupted horizon. Valuable and interesting results would doubtless be obtained if observations with recorders placed at various elevations above the ground in an open situation were carried out with the object of determining what effect, if any, elevation above the earth's surface had upon the registration of sunshine.

Mr. G. J. Symons, referring to Mr. Backhouse's inquiry, said that Mr. Glaisher had fully discussed the question of the diurnal variation in the amount of cloud, and the results of his investigation were to be found in the *Diurnal Range Tables*, which Mr. Glaisher published many years ago.

The President (Mr. R. Inwards) said that with regard to the general question of sunshine recording, he would like to know whether any Fellow of the Society had attempted to make direct observations of the effect of sunshine on the growth of plants. He remembered that at the Society's Exhibition of Instruments in March 1891 an ingenious apparatus for weighing growing plants was shown, the arrangement being, he believed, but a carrying out in detail of the suggestions of the Dutch author, J. Ingen Housz, who wrote in 1729. He (Mr. Inwards) would also like to know whether any observations had been made as to the effect of wind on the sunshine recorder itself, as it was easy to see that there must be great differences of exposure to wind at the various stations.

Mr. R. H. Curtis, in reply, said it would be of great interest to study the diurnal variation of sunshine in connection with the diurnal variation of temperature, wind-force, rainfall, and barometrical pressure, to each of which he thought it would show some degree of correlation. In connection with such a study it was most important to bear in mind the physical features of the district represented by the record, because there could be no doubt but that these exercised a very direct influence upon the amount of sunshine experienced, as they did also upon the march of the other phenomena which he had named. The necessity for a perfect exposure was emphasised by the peculiarity in the Armagh record, to which he had referred. There were districts in which it was impossible to obtain a perfect horizon for the recorder owing to hills, but such hills formed a natural feature which affected the sunshine "capability" (to repeat the term he had used in the paper) of that particular district, and as such it had to be taken into account. It was not, however, to such obstructions that he now referred, but to others of a local and artificial character, such as trees and buildings, and which affected only the actual place of the recorder, and not in any way the district it professed to represent. The shadow cast on the card at Armagh was but for a few minutes each day, and only during a few weeks in spring, and again in autumn. It was by no means easy to detect it by inspection of the records, and it would scarcely make itself felt in the mean daily amount

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for the months affected; but it became very conspicuous in dealing with the hourly amounts, and under some circumstances might easily prove very misleading. Some speakers had apparently thought that the flattening of the curves in the middle of the day indicated an increased cloudiness then, but that was not necessarily so; it showed an equal distribution of sunshine over the middle hours of the day, but that might conceivably represent *less* cloud in the morning and afternoon rather than *more* cloud at midday. He did not consider that the smoke of Glasgow would wholly account for the greater sunnyness of the afternoon as compared with the morning hours, although doubtless it did so to a great extent. The prevailing winds would blow from the observatory towards the city, and the diurnal increase of wind-force, which corresponded very fairly with that of sunshine, would tend to clear the smoke away from the observatory, and to that extent might be held to account for the phenomenon; but a similar phenomenon was shown at Falmouth also, where smoke could not be possibly made to explain it, and therefore he was led to believe that smoke was not the only cause involved in it. With reference to Mr. Symons' remarks as to a "hypothetical altitude" as a standard of intensity, he might mention that occasionally in winter the burn made upon the card was equally as broad as in summer; wind-force he did not think influenced the burn at all. On the whole, he was of opinion that the Stokes' form of instrument was the best, especially if improved in one or two details, as could easily be done; to the "universal" form he had some objections, and he had several times found these instruments out of proper focus.

THE FREQUENCY, SIZE, AND DISTRIBUTION OF HAIL AT SEA.

By HENRY HARRIES, F.R.Met.Soc.

Mem. German Met. Soc.

[Received May 7th.—Read June 19th, 1895.]

When reading the Hon. Rollo Russell's comparatively recent work *On Hail*, it occurred to me that the author, in the absence of either positive or negative information, had fallen into an error in his treatment of one branch of the subject, namely, that of the occurrence of hailstorms out on the ocean. Having had much to do with maritime weather records, I felt sure that a general examination of some of them would reveal facts at variance with the conclusions arrived at in the book referred to.

The references to falls of hail are confined almost wholly to those observed on land, the numerous authorities quoted evidently contenting themselves with land records, and Mr. Russell has thus been unwittingly led to suppose that hail is essentially a land phenomenon.

On pages 57 and 58 there is an extract from the *Philosophical Magazine* giving a brief account of "a shower of ice in irregular pieces" which lasted three minutes, at a distance of about 800 miles south of the Cape of Good Hope. Page 94 contains a reference to showers of hail "in the Atlantic"

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in December 1869, but no information is given as to whether the falls were north or south of the Equator, in mid-ocean or close inshore.

These constitute the sum total of the instances of ice or hail on the water, and when we remember that the extracts cover a period of more than two centuries, it is not surprising that Mr. Russell should have decided, in Chapter VI., "Summary of Characteristics of Hailstorms and Hailstones," page 154, that "in mid ocean it [hail] is uncommon;" and again in Chapter VII., "Conclusions," we have the upshot of the discussion of a multitude of theories and conjectures resolving itself into a law which declares (page 202) that "the equability of the ocean temperature, and the usual absence of comparatively very cold masses of air at a high level, will rarely allow the development of great hailstorms over the open sea." It really looks from these extracts as if we ought to regard the only two falls mentioned as being merely accidental circumstances which should not have occurred in a properly constituted oceanic atmosphere. The book contains nothing to show that mariners have supplied evidence proving that hail is a stranger to them, neither are there any data to support the notion as to "the usual absence of comparatively very cold masses of air at a high level" over the ocean.

I am not going to propose any theory regarding hail at sea; my object in contributing this paper to the Society is simply to place on record a few facts gleaned from original and authentic sources which will satisfy Mr. Russell that his theories cannot be justified.

As is well known, mariners have for more than 40 years been registering systematic weather observations for the Meteorological Office, and several thousands of the logs are stored in Victoria Street. The information on which this paper is based has been obtained from a few of these manuscript volumes, the Meteorological Council readily granting me permission to inspect the logs for the purpose.

To discuss the entire collection would manifestly be beyond my powers, and for the immediate object in view such an elaborate inquiry is quite unnecessary. For testing the frequency, what I have done is this. The logs of 18 vessels visiting the southern oceans were taken in the order in which they came to hand, and without any attempt at selection for the sake of the quantity of observations they may contain. The volumes related to the years 1871, 1875, 1876, 1877, 1878, 1880, and 1881. Going through the column headed "Weather," the entries of the letter "h" were noted. Of the 18 vessels one proved to be a steamer running between Lisbon and Rio de Janeiro, no hail being registered. Three of the observers made use of "h" to represent both "hail" and "haze," and were consequently disqualified. One of these gave as many as 55 entries of "h," 30 of which were undoubtedly hail, because they were confirmed by definite statements in the space for remarks, but the remaining 25 were too doubtful for use. I had consequently the logs of 14 ships to deal with. A dozen of them sailed down the South Atlantic for Asiatic, Australian, or New Zealand ports, the other two going round Cape Horn. All of them experienced hail, the 12

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which went into east longitude recording, between the meridian of Greenwich and the 180th meridian, and at the ordinary four-hourly periods, 177 entries of "h," or an average of 15 each, one ship having 29, another 30, and a third 32. In the more open part of the Indian Ocean, between 30° E. and 120° E., with only two or three infinitely small specks of islands in the whole space, 118, or 67 per cent., of the hail observations were noted. As ships do not usually go very far south in crossing the Indian Ocean, nearly the whole of the hail recorded was on the equatorial side of the 47th parallel, and about a sixth of the total number of observations on the northern side of 40° S.

Five of the ships in the South Pacific, between 180° and 70° W., recorded hail 38 times, most of them on the polar side of 50° S., but a few to the northward of 40° S.

The logs also contain observations of hail in the North and South Atlantic, and the North Pacific, the 14 observers recording on their out and home passages a total of 114 days with hail. If we accept the theory which tells us not to expect hail at sea, an average of eight days per ship per voyage is very high indeed. But I have glanced through scores of other logs, and I believe I am justified in saying that the results deduced from these chance 14 registers give a very fair general average, hardly any of the ships escaping hail at some stage or other of a voyage in the open southern oceans, some registering it very much more frequently than any of those included in the foregoing summary. Thus, one observer on the way to New Zealand and home entered "h" 66 times—outward, 5 in the North Atlantic and 16 in the Indian Ocean; homeward, 31 in the South Pacific, 9 in the South Atlantic, and 5 in the North Atlantic. Another had 21 entries between 4° E. and 49° E., in 37° S. to 39° S.; while an observer giving weather entries regularly every two hours recorded hail 35 times while running from 10° to 139° E., in 44° to 48° S.; another as many as 96 times within 16 days between 51° E. and 165° E., in 43° S. to 49° S. Of this very large number, 12 were underlined once, 12 twice, and one thrice, the underscoring denoting intensity. Further, 45 of the entries were within five days, 10 being heavy, and 12 very heavy. On the homeward run across the South Pacific the same observer gave 20 entries of hail in five successive days, so that we have a single observer with 116 records while running about two-thirds the distance round the southern hemisphere.

It must be borne in mind that these records are merely from chance visitors to any particular locality, and this fact must be taken into account in any attempt at comparison between sea and land data. The great, the remarkable, frequency of hail in the Indian Ocean is, however, fully confirmed by the log of H.M.S. *Erebus* for the period of the stay in Christmas Harbour, Kerguelen, from May 12th to July 20th, 1840. Out of the 70 days hail fell on 24; in May 10, in June 11, and in July 3, there being in all 64 entries of hail, the weather records being hourly as a rule. Is there any fixed station in Europe which can, for its worst hailstorm year, equal this mid-ocean return?

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In the foregoing I think I have brought forward quite enough evidence to negative the assertion that hail at sea "is uncommon."

Nor is the undoubted frequency of hail the only feature worthy of attention, for, contrary to another portion of Mr. Russell's theory, great hailstorms are often met with on the open ocean. My difficulty has not been to discover accounts of severe storms, but to select a few typical examples of what we may regard as not uncommon occurrences. Figures have already been given showing the proportion of moderate, heavy, very heavy, and excessively heavy hail experienced in the South Indian Ocean during a run from west to east. Taking another register in the same neighbourhood, and for another year, I find that out of 14 days, between 59° E. and 186° E.; in 44° S. to 47° S., hail fell on 10 days. On one day there was a considerable fall of hail and snow; later the observer remarked: "Several times during the night the decks were covered an inch deep with hail and snow;" next day hail fell most of the time, snow or hail falling for three hours almost without cessation. A few days after great quantities of hail fell in frequent heavy squalls.

A Fellow of this Society, Capt. A. W. Jeffery, of the s.s. *Ptolemy*, experienced a severe hailstorm on March 14th, 1883, in 41° N., 43° W., fairly in mid-Atlantic. "11.45 p.m. squall force 9 lasted 40 minutes, and wind flew to the North-west. During this squall the lightning was very vivid, and the hailstones of an immense size, so much so that the helmsman could not hold the wheel, and the ship's head was turned to the southward for 30 minutes till the hail ceased."

Capt. Peebles, of the four-masted barque *Tweedsdale*, on August 17th, 1883, in 39° S., 21° E., reported:—"9.30 p.m. a thunderstorm burst over us, incessant lightning seemed darting through the gear, peal after peal of thunder shaking the whole ship. For about 15 minutes had a tremendous fall of hailstones as large as pigeons' eggs."

On the barque *Margaret Wilkie*, Captain Gibbs reported a hailstorm on October 26th, 1875, in about 37½° S., 22° E. At first the stones were from the size of a pea to that of a horsebean, but afterwards they became larger and thicker.

Capt. Gray, on the barque *Shun Lee*, August 25th, 1881, in 34° S., 28° W., noted:—"7.30 p.m. sky commenced to cover with a dense nim. cloud from South-west, and which by 8 p.m. hung like a dense pall, making an intense darkness. As soon as well overhead, hail as big as large peas came down in a perfect avalanche, covering the poop about 2 inches in a few minutes. As it passed it changed to rain." When commanding the barque *Speranza*, Capt. Gray had a fall of large hailstones in February 1873, in 57° S., 76° W., and on May 22nd, 1873, in 44° S., 77° W., "had some hard hail and sleet squalls, some of the hailstones as big as a nut. Had very heavy hail and sleet squalls at short intervals, but at 8 p.m. had a most terrific one. Kept away with reefed topsails on the cap, and then it seemed as if it would bury the ship. Had a similar one, not so heavy, at 6 p.m." Again in the following November he had a heavy fall of *lumps* of jagged-edged pieces of ice, some of them an inch long, in 42° S., 60° W.

In six days in April, while sailing along the 50th parallel of south latitude between 178° E. and 158° W., Capt. J. P. Holdich, R.N.R., of the ship *British Envoy*, gave 24 entries of "h." At 7 p.m. on April 22nd, in 159° W., he had a tremendous fall of hail, the poop deck being covered to a depth of 3 inches in 20 minutes.

On the homeward passage from San Francisco, in May 1882, Capt. Hughes, of the ship *Laomene*, gave 13 entries of hail in 15 weather observations, from 8 p.m. 10th to 4 a.m. 13th, between 82° W. and 67° W. in 56° S., remarking that heavy hail fell about every three-quarters of an hour, and lasting 10 or 15 minutes, the falls covering a period of 41 hours, from noon 10th to 5 a.m. 13th. Again from 9 p.m. 23rd to 8 a.m. 25th, in 47° S., 46° W., to 44° S., 41° W., he had nine entries of heavy hail which fell in squalls every half or three-quarters of an hour.

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Another vessel rounding Cape Horn in August 1872 spent 15 days between 56° S., 67° W., and 49° S., 80° W., with 25 entries of hail, the observer remarking, "One thing I consider worthy of note, that we have had no really heavy rain, but certainly a great quantity of hail and thick weather."

In January 1860 Capt. Sweet, of the ship *Pizarro*, had hailstones as large as small nuts in a heavy fall in 43° N., 14° W.; and in June 1868 Captain Banner, of the barque *Lady of the Lake*, had very large hailstones in a thunderstorm in 40° S., 89° W.

Capt. Atkinson, of the *Priorhill*, in April 1888, had 12 entries of hail in 43° S., 100° E. to 110° E., remarking that the hailstones were the size of small marbles.

On May 14th, 1873, in 36° N., 71° W., Capt. McRitchie, of the ship *Assaye*, had "one of the most awfully grand thunderstorms," with heavy squalls of rain and hail, some of the hailstones being as large as walnuts. In the previous October, in 38° S., 2° E., he had had hailstones as large as marbles.

Capt. James Gales, of the *Florence Nightingale*, in March 1857, in 56° S., 66° W., had two kinds of hail falling, one small and round, the other large and angular, and striking with great force. Near the same position, 57° S., 64° W., his brother, Capt. Isaac Chapman Gales, in October 1868, had "sharp showers of large snowballs, not hail proper."

On November 15th, 1863, Capt. Kerr, of the *Jane Henderson*, in 35° S., 26° E., remarked, "At 6.30 p.m. an immense waterspout formed suddenly in the west, about two miles distant, and bore rapidly down upon the ship. She was steered to the south in the hope of clearing it, but it approached within three ships' lengths and discharged pieces of ice upon our decks, about 2 inches square (not in balls, but flat). This was immediately followed by a terrible flash of lightning and sharp rattling thunder, a deluge of rain, and a furious squall."

Not far from the same spot, 35° S., 24° E., Capt. Wight, of the *Dunalistair*, on July 5th, 1876, had the lower part of a waterspout cross his bows, his weather column showing very heavy squalls, with thunder, lightning, hail, and rain, from 8 a.m. to 8 p.m., noting in the remarks that "the hail was like a ball of clear ice."

In May, 1891, Capt. Randall, of the *Laomene*, in 39° S., 29° E., had a terrific thunderstorm from north-east, with showers of hail and ice.

A tremendous thunderstorm broke over the ship *Martaban*, Capt. Gun, on August 16th, 1872, in 45° S., 121° E. "The hail and snow seemed to come in lumps, striking the face like snow balls."

Capt. Wilson, of the barque *Horsa*, experienced a violent squall, with lightning, on November 11th, 1884, in 41° S., 49°E. "It brought a perfect torrent of pieces of ice like splinters ½-in. in length."

The Society's *Quarterly Journal*, Vol. XX. page 172, contains an extract from the Meteorological Office log of the s.s. *Anglian* relating to a heavy hail and thunderstorm in the Bay of Biscay, the hailstones being as large as walnuts, many an inch and two of them 1½ in. in diameter.

I might, however, fill a whole volume with notices of very heavy, terrific, or tremendous falls of hail far away from land; of stones varying in size from large peas to walnuts and pigeons' eggs; and of pieces of ice up to 2 inches square—but the examples quoted amply suffice to prove that great hailstorms on the ocean are not such altogether exceptionally rare events.

Another branch of the question is that of the distribution of hailstorms at sea. Mr. Russell is evidently content with the view expressed by Prof. Fritz, which he quotes at page 74—"Hail is confined to middle latitudes," the maximum hail-fall being between the latitudes of 40° and 60°—of course, on land.

So far as my knowledge of the contents of the meteorological logs goes, I have no hesitation in asserting that on the open ocean hail is not only exceedingly common in occurrence, but also more frequent and in greater

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quantities than on land, the region of abundant hail being on the polar side of the 35th parallel of latitude in both hemispheres, the logs yielding records in abundance. Between the 35th and the 30th parallels there is a perceptible falling off in the frequency, but still, when we consider the latitude, it is by no means uncommon for vessels to be overtaken by more or less heavy hailstorms. Within these limits, and only on the most cursory inspection of a number of logs, I have noted scores of observations of hail, but I will only refer to a few of them to show the various localities in which they have been met with, as well as to prove that they are not trifling falls.

In a strong Northerly gale on February 7th, 1876, Capt. Gillmoore, of the ship *Melpomene*, had heavy hail entered at 8 a.m. and noon, in 34¼° N., 36½° W., air temperature 50½°, sea 61½°.

Captain Rowsell, of the R.M.S. *Tagus*, experienced a heavy hailstorm on August 8th, 1888, in 34¾° S., 58° W. (entrance to the Rio de la Plata), the thunder and lightning being incessant, and the hailstones of the size of eggs.

During a severe Westerly gale on July 15th and 16th, 1855, Capt. Cowell, of the ship *Anna*, had for 14 hours a succession of hail falls in squalls and thunderstorms, between 29°15′ S., 40½° W., and 30°40′ S., 41° W.; and again in the night of the 21st-22nd, in 34½° S., 49° W., he had heavy showers of hail and of sleet.

On January 13th, 1877, one of our Fellows, Capt. Greenwood, ship *Gareloch*, had a sudden shift of wind from East into South-west, with heavy squalls of large hailstones in 32°53′ S., 29° W.

Capt. Gray's experience in 34° S., 28° W., has already been quoted.

In 31° S., 27½° W., Capt. Stuart, of the ship *Otago*, had a heavy shower of hail on the morning of August 30th, 1873; and at midnight of September 1st, in 32° S., 20° W., Capt. Tully, of the ship *Baroda*, had very heavy hail showers.

On June 12th, 1856, Capt. Tate, of the ship *Meroo*, had heavy hail squalls in 32°5δ′ S., 17° W.

The log of the barque *Result* shows sharp squalls of hail on August 14th, 1865, in 33°54′ S., 14° W.

On November 24th, 1885, Capt. Russell, of the ship *Khyber*, had frequent heavy hail squalls at intervals of about 20 minutes in 34½° S., 9° W.

Capt. Scougall, of the barque *Closeburn*, had several falls of hail in 34° S., from 1° E. to 3½° E., on September 9th, 1891.

A furious squall from South-west, accompanied by hail, struck the ship *Riversdale*, Capt. Maples, on June 16th, 1875, in 31½° S., 12° E.

On the ship *Amana*, May 15th, 1888, Capt. Becket had heavy squalls of rain and hail between 33¾° S. and 38¼° S., in longitude 15° E.; and on June 27th, 1878, Capt. Ellery, of the ship *Baroda*, had heavy squalls of hail and rain in 32½° S., 16° E., air temperature 51°·9.

I have thus, without exhausting my list, run a line across the South Atlantic from 58° W. to 16° E., but in the Indian Ocean an equally complete chain of short links would be difficult to obtain, owing to the fact that ships follow closely certain well-defined narrow tracks in making for Asiatic ports, and again on their homeward voyages.

About the edge of the Agulhas Bank, off the south-east of Africa, and between 30° S. and 35° S., hail often falls, observers describing the storms as "severe," "violent," "terrific," and so on, the stones frequently being noted as large.

It will be sufficient to give an extract from the log of the barque *Kingdom of Saxony*, Capt. W. C. Smith. At 10 a.m. on July 17th, 1874, in 31°25′ S., 31°50′ E., "there fell a shower of the largest hailstones I have ever seen; not

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like ordinary hail, but bits of ice; not of whitish colour, but like glass." Next day, in 30°53′ S., 32° E., there were squalls of very heavy rain and hail.

Further out on the ocean we have Capt. Quirk, of the ship *Mencius*, reporting a severe gale with violent squalls and heavy hail showers, in 31° S., 38° E., on June 27th and 28th, 1856; and a few days later, on July 1st, in 31°40′ S., 41° E., Capt. Liddle, of the barque *Bride*, had very heavy squalls of hail and rain.

Capt. Clement Mossop, of the ship *Candahar*, on April 18th, 1868, was in a heavy southerly gale in 34° S., 74° E., recording squalls of hail and rain.

At 3 a.m. on May 20th, 1856, Capt. Fox, of the ship *Anne Royden*, in 31° S., 81° E., noted, "Squall arose looking very threatening, but instead of much wind it turned into a heavy fall of hail, one flash of lightning, and a clap of thunder. This fall of hail continued three-quarters of an hour."

In 32° S., 96° E., Capt. Fawcett, of the barque *Staghound*, on August 18th, 1877, registered hail squalls in two observations; and on September 3rd, 1875, the ship *Beemah* had violent hail squalls in 32½° S., 97° E., hail falling nearly all day.

From these records it is fair to conclude that between 30° and 35° S. there is a possibility of meeting with hail all along the ocean from the American to the African, and from the African to the Australian coasts.

Not having handled many Pacific logs entering these limits of latitude, I can only say that the few I have seen strongly support the records in the other oceans, there being records of hail in the South Pacific at different stages between 32° and 34° S., from 152° E. to 95° W., an exceptionally severe hailstorm, extending over 24 hours, being recorded by Captain Price, of the barque *Viola*, on July 22nd and 23rd, 1887, in 33° S., between 106° and 102° W. In corresponding latitudes in the North Pacific the entries seem to be fairly numerous in the western half of the ocean, Capt. Fawcett of the *Staghound*, in February 1878, registering hail eight times in 11 consecutive weather observations between 34° and 35° N., 178° to 180° E.

On the eastern side of this ocean H.M.S. *Satellite*, on August 8th and 9th, 1860, had three entries of hail between 29½° N., 119½° W., and 28½° N., 118° W., the winds being North-west to North-east light, and the air temperature 66°at 8 p.m., 8th, and noon, 9th, and 65° at 8 p.m., 9th.

Having thus made it perfectly clear, I hope, that we are not warranted in regarding hail as an altogether unusual phenomenon on the sea in the Northern and Southern Hemispheres above the 30th parallels of latitude, I must add the few instances of falls nearer the Equator which have come under my notice. Of course, it will be understood that I have not attempted an exhaustive search of the logs handled, my original intention having been to obtain a general idea of the frequency of hail in the more southern part of the Indian Ocean, the size and distribution being an afterthought when I found frequent mention of storms much nearer the Tropics than the latitude of 40°.

If we think of the influence of the great winter anticyclone over Siberia on the climate of South-eastern Asia we shall all be prepared to find colder weather off the Chinese coast in the early months of the year than is to be met with in similar latitudes in other seas. This influence is strikingly exhibited in the low temperatures, and the snow and hailstorms experienced by ships at some distance from the land between 20° and 30° N.

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In a strong North to North-west gale, in about 30° N, 123° E., on February 1st and 2nd, 1862, Capt. Peter Slaughter, of the ship *Spray of the Ocean*, registered 15 consecutive entries of hail, sleet, or snow (8 of hail), the air temperature sinking to 32°.

On February 3rd, 1856, Capt. Quirk encountered a gale in 29½° N., 124¼° E., with several showers of hail and small snow, the temperature of the air dropping to 41°.

A degree nearer the Equator, in 122° E., on February 26th, 1886, Capt. Pearson, of the s.s. *Strathleven*, had constant showers of mixed hail and rain.

Running down the Formosa Channel for Hong Kong, Capt. Metcalfe, of the White Star liner *Oceanic*, had a succession of hail showers on January 20th and 21st, 1884.

Perhaps it goes against the grain with some, if not all of us, to admit that hail can fall at sea within the Tropics, but I think we have enough data to show that such precipitation is possible.

On April 30th, 1883, in 23° N., 117° E., during a moderate gale, the weather was dull and gloomy, with squalls of hail and very heavy rain, temperature falling from 76° to 73°.

Capt. Dulling, of the s.s. *Port Phillip*, had very dull heavy weather on August 24th, 1885, the sky being overcast with nimbus; temperature at 4 a.m. 83°, 8 a.m. and noon 84°. At 2 p.m. he remarked that the atmosphere was disagreeably sultry, with a nasty haze on the horizon; and at 4 p.m., with nimbus, amount 9, the weather was "oqrh," temperature 78°, the 8 p.m. reading being 84°, and at midnight 88°. The position at 4 p.m. was 20°58′ N., 125°45′ E., a considerable distance south-eastward from the southern extremity of Formosa.

When, however, we go into other parts of the world, where we have totally dissimilar atmospheric conditions prevailing, it may not be so easy to account for hail as it is in the neighbourhood of the China Sea.

Capt. Kerr, of the ship *Ardgowan*, had very heavy squalls of hail and rain on May 24th, 1874, in 29° S, 38½° E.

The P. and O. barque *Indus*, Capt. Lee, was in a violent Southerly gale on May 17th, 1866, and at 10 a.m., in 29°30′ S., 41°38′ E., there were showers of hail in tremendous squalls. At 8 p.m. and 10 p.m. on the 16th the air temperature was 72°, but at 10 a.m. on the 17th the reading was 60°, 2 p.m. 58°·5, 4 p.m. and 6 p.m. 59°·4, and at 8 p.m. 58°; sea temperature changing but slightly—73° to 74° during the day. The gale continuing on the 18th, there was another severe squall with hail at 10 a.m., in 28°58′ S., 40°35′ E., the air temperature being 61°·5. These falls occurred at a distance of about 300 miles from the southern point of Madagascar, and about 500 miles from the African coast.

A remarkable hailstorm was experienced by the barque *Minero* in the South Atlantic on July 6th, 1871. Throughout the preceding night the weather had been very bad, sky heavily clouded, with very heavy thunderstorms and rain. At noon, in 26°27′ S., 39°49′ W., Capt. Carruthers remarked, "After 8 a.m. could see the cum. packed in south-west horizon; overhead covered with cloudy blackness, through which you can see cum. To the west heavy black clouds which passed over about 11 a.m., with excessively heavy thunder and lightning, also *hail* of extraordinary size, some of it quite half-an-inch square; it was irregular in shape, and the heaviest of it lasted 10 minutes." The temperature of the air was not greatly affected by this fall; it was at 69°·9 on the 5th, at noon, and by 4 a.m. 6th, it was 64°·2, rising to 66°·9 by 8 a.m., falling to 64°·8 at noon, and going up to 67°·9 by 4 p.m. Sea temperature altered very slightly during the two days; 8 a.m. of 6th it was 70°, noon 70°·4, and 4 p.m. 70°·9.

Twenty-two miles inside the Tropic of Capricorn, in 23°6′ S., 36°40′ W., on July 10th, 1855, Capt. Cowell, of the ship *Anna*, entered in his weather column "c hailstones," and stated in the remarks, "At 5.30 p.m. we had a few hailstones, weather very squally, wind from South-west to West." Temperature at 3 p.m. was 71°, and at 6 p.m. 69°. Five days later, as already mentioned, the same ship had several falls of hail between 29° and 30° S.

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Approaching still nearer the Equator, my next illustration is found far out in the Indian Ocean, and once more our authority is Capt. Greenwood, F.R.Met.Soc.

On April 14th, 1878, the ship *Gareloch* was on the outer edge of a cyclone, the sky very cloudy, and the wind increasing from the Southward. At 8 p.m., in 21°15′ S., 66°50′ E., with wind South-south-west 5—7 ; air temperature 79° ; cloud form, Str ; amount 10—6 ; and the weather given as "ch," but no comment made in thes pace for Remarks. At midnight, wind South-east 5—8 ; temperature 77°·5 ; cloud, Str, 10—7 ; weather "cbg ;" remark, "Hard squall, wind veering to South-east and East." Were there nothing else to guide us than the bare record for the day, scepticism as to the meaning of the "h" entered as above would be natural, but the log itself is pretty conclusive evidence that the letter was correctly entered for hail, every instance, and there are many of them, of the weather being hazy during the voyage out and home having "m" as its equivalent in the weather column. Even this proof may by some be thought not to determine the point absolutely, for it might be argued that for once the observer had made a slip of the pen. As the case is manifestly a very interesting and important one, I have made assurance doubly sure by an appeal to Capt. Greenwood himself, and he has very kindly gone into the question. The incident having occurred more than 17 years ago, he has not trusted to his memory, for he does not remember it as one of the great events of his life at sea, but he has consulted his private journal for the period, and satisfactorily settles any doubt we may have on the point. He writes to me: "Although there is no entry in the remark column in respect to this incident, I think—nay, indeed, I am sure—that you may accept the entry as a genuine one, and for the following reason :—Throughout my meteorological work I invariably used only the letter "m" for mist or haze, and "h" for hail. In this case the letter is distinctly a capital "H." It was, and is, always my custom to put the letter as a capital in the weather column of my private journal or note book when the phenomenon to which it relates is, what I think, extraordinary. This I evidently thought at the time."

Curiously enough, the remaining tropical records are very much like that of Capt. Greenwood, in that they are not specially commented on in the Remarks.

Capt. McBride, of the ship *Frank Flint*, entered in the weather column at 4 p.m. September 5th, 1875, "gqoHl," the position being 12° 55′ N., 26° 25′ W. The conditions were unsettled, the ship having been under the influence of a cyclone on the previous day, and about the time of the entry in question the wind, which had before been at South and South-west, came out at North, very light, the sky being overcast with cumulo-stratus and nimbus. The log contains several instances of haze represented by "m," and hail by "h," but here the observer gives a heavy capital H.

On February 6th, 1856, the ship *Queen's Hill*, Capt. A. D. Wood, was in a cyclone at the northern extremity of the Mozambique Channel. I cannot do better than present in tabular form the particulars as entered in the log. The position at noon on this date was 10° 29′ S., 43° 28′ E., and at 8 p.m., 10° 59′ S., 43° 42′ E. (p. 239.)

A few days later, on the 9th, Capt. Wood remarks, "These last five days have been excessively disagreeable as regards weather." It will be seen that no reference is made to hail in the remarks, but the general character of the weather points to "h" having been used correctly. In other parts of the log the letter has the recognised signification, and so far as I am able to judge the entry ought to be accepted as a record of hail.

The ship *Seringapatam*, Capt. Carrey, had the weather "opqrth" on May 5th, 1877, in 7°58′ N., 74°17′ E.

Whether these are or are not intended for hail in each particular case, I think we must, on consideration of my final tropical illustration, banish the word "impossible" from our minds. I find Capt. Houston, of the ship *Florence*, giving the following significant facts in his log for May 29th, 1871. At 8 a.m. the ship was 10 miles south of the Equator, in longitude 90°23′ E., with "very heavy rain which was like ice drops." From 4 a.m. to 8 p.m. the temperature of the sea water was 84°, the air temperature being 80° at 4 a.m., 78° at 8 a.m.

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Hour.	Wind.		Air Temp.		Cloud—Amount.	Weather.	Remarks.
	Direction.	Force.	Dry.	Wet.			
			°	°			
Noon	N	5	83·4	78·2	10	..	Noon—Strong wind with squally appear-
2 p.m.	NNW	6	..	..	..	..	ance. 1 p.m.—In maintop gallant sail
3 ,,	WNW	10	77·5	75	..	..	and mizzen top sail, and double reefed
4 ,,	W	7	78	..	10	q^2R	fore and main topsails. 2 p.m.—A very
6 ,,	NW	6	77·5	75	..	q	heavy black squall with deluging rain;
8 ,,	NNW	6	79·3	76·2	10	..	obliged to keep dead before it. Re-
10 ,,	,,	8	80	..	..	hm	mainder blowing very hard with heavy
Midt...	,,	8	79·2	76	10	..	squalls; could not bring the ship by the wind, and abandoned the intention of going to westward of Comoro.

and 81° at noon and 4 p.m. When, however, the temperature of the rain water was taken it was found to be 52°, or 32° colder than the sea. There is nothing in the log to show whether the temperature was that of the rain as it fell, or whether it was obtained by collecting a quantity of water in a bucket or some other vessel. In the latter case we can quite understand that a delay of a few minutes would mean a difference of some degrees in the record. Taken as it stands, the observation is one which indicates that we are not to be astonished if some day we unearth a notice of a hailstorm at sea right on the Equator.

As regards the question of polar frequency, Mr. Russell concludes (page 62) that "Hail is almost or quite unknown in the Arctic Regions," and that "Thunderstorms may be said to be equally rare;" and on page 154 we are told that "In the Arctic Regions hail is almost unknown." Now Arctic and Antarctic observations are not so numerous as to justify our arriving at any definite decision. The few logs I have handled for latitudes between 60° and 65° in the Northern and Southern Hemispheres contain a fair sprinkling of hail records, but of Arctic logs I have only chanced to alight on one—the meteorological register kept by Mr. Arnold Pike on the yacht *Siggen* during a northern cruise in 1894.

On May 16th, in 73° N., 18° E., there were showers of snow and hail at 8 a.m. and noon. At noon on the 22nd "a very little soft hail fell;" at 8 p.m. showers of soft hail; next day at 6 p.m. "very fine snow, resembling small hail;" and 8 p.m. ditto, the ship during these two days being between 75¼° and 76¼° N. 14° and 16° E. Off the southern cape of Spitzbergen at 4.20 a.m. on June 1st, Mr. Pike recorded "snow or ice, like pieces of horsehair, about ¼-in. long, fell for 10 minutes," and from 4 a.m. to 10 p.m. "a very few flakes of snow or ice at times." At 9.15 p.m. on the 3rd, in the same place, he had "slight snow until 11.30 p.m. (like short pieces of hair)." On August 19th, in 72½° N., 36¼° W., there was distant thunder in east-south-east at 5 p.m., and at midnight there is a remark "distant thunder in south-east all the afternoon. From 10 p.m. to 10.40 p.m. a severe thunderstorm, with rain, passed overhead from south-east to north-west."

Far be it from me to accept this record as deciding that every ship going beyond the latitude of 70° must necessarily experience hail and heavy thunderstorms, I merely give the facts to show that the phenomena are at least not "quite unknown"—an occasional visitor can prove nothing more.

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I have now shown that hail is possible at sea in all latitudes as far as ships go north and south of the Equator, and that over wide belts on the polar side of the 35th parallel it is familiar to seamen. What we want next is a theory which can be reconciled with the abundant testimony available.

NOTE.—JUNE 19TH, 1895.

Since this communication was placed in the list of Papers for discussion at this Meeting, I have consulted the following publications containing information bearing upon the question of hail at sea :—

(1.) *Remarks explanatory of the Charts of Meteorological Data for the Ocean District adjacent to the Cape of Good Hope*, Official No. 48, published by the authority of the Meteorological Council. Appendix II., pp. 78-84, gives, in tabular form, the frequency of the various weather elements, clouds, &c., in spaces of 5° of latitude by 10° of longitude for each month of the year. There are a number of instances of hail forming from 10 to 31 per cent. of the weather observations.

(2.) *Die Aequatorialgrenze des Schneefalls*, a paper by Herr Hans Fischer, in the Leipzig *Mittheilungen des Vereins für Erdkunde* for 1887, pp. 99-274. This is a discussion of the equatorial limits of snow on land and sea, but Herr Fischer has included a large number of hail records in the extracts he gives from the meteorological logs at the Deutsche Seewarte and from other sources. They are tabulated separately for each ocean for the winter months, and in the main confirm the results arrived at in this paper. In the North Atlantic he gives hail down to latitude 32° N., in the North Pacific to 31° N., in the South Atlantic up to 34½° S., and in the Indian Ocean to 33° S.

(3.) *Waarnemingen in den Indischen Ocean*, Koninklijk Nederlandsch Meteorologisch Instituut, Utrecht. This publication is to consist of four volumes of charts showing, for the Indian Ocean, the results obtained from a discussion of various meteorological data, the two volumes representing respectively the months December to February and March to May having already been issued. One chart is devoted to hail percentages, and from this it is evident that over such a long period as three months there are portions of this open ocean, far removed from land, where hail forms 25 per cent. and upwards of the weather records.

Having given only one reference to North Polar observations, it may be of interest to add another for the Antarctic regions. In the log of H.M.S. *Terror* I find several entries of hail beyond the 60th parallel to within 16° of the South Pole, or nearly to the most southern point reached by Sir James Ross. Hail was experienced on January 21st, 1841, in 74° 12′ S. 170° 45′ E., and on February 25th, 1842, in 74° 12′ S. 167° W.—H. H.

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DISCUSSION.

The Hon. F. A. R. RUSSELL said:—In the first place I wish to express the pleasure with which I have heard the paper which has just been read. It deals with a subject on which hitherto very little light has fallen from authentic sources, and certainly no such maritime records as have been quoted were within my knowledge when I wrote my book *On Hail*. Now it appears that mariners have for more than 40 years been registering systematic observations for the Meteorological Office, and that several thousands of logs, some of which make mention of a phenomenon such as hail, are stored in Victoria Street. These logs must contain many treasures, and one can only rejoice when, as we have seen to-night, these "gems of purest ray serene" are brought to the surface and set in the sunshine of our Society.

Before proceeding to discuss Mr. Harries' paper, it may be well to distinguish —for perhaps I have not sufficiently done so in my book—between large and small hail. It was the large or summer hail with which I dealt; disregarding the small hail, graupel, or sleet, of cool climates or seasons. Mr. Scott, in his *Elementary Meteorology*, says, "Soft hail falls chiefly in winter and spring. True hail is a very different thing. It is usually composed of concentric layers of hard and soft ice," &c. . . "In these islands, fortunately, we know but little of destructive hailstorms. On the Continent we are almost everywhere met by the frequent advertisements of Hail Insurance Offices, which are comparatively rare here. This immunity of ours is due to our insular climate, and its consequent freedom from extremes of temperature."

Only two instances, Mr. Harries states, are given in my book of a hailstorm on the water, and he then infers that since the extracts cover a period of more than two centuries, it is not surprising that I should have decided that "in mid-ocean it is almost unknown." Yet I know well that many great hailstorms might occur at sea, while an accurate description of one of them might still be wanting. Further, when referring to my "Summary of Characteristics of Hailstorms and Hailstones," he quotes me as having written "in mid-ocean it [hail] is almost unknown." The actual words are different: "In mid-ocean it is uncommon," the previous sentence being, "In the Arctic regions hail is almost unknown," so that a distinction is clearly drawn between "almost unknown" and "uncommon." Then he speaks of the upshot of theories and conjectures discussed in the book resolving itself into a *law* which declares (p. 202) that "the equability of the ocean temperature and the usual absence of comparatively very cold masses of air at a high level will rarely allow the development of great hailstorms over the open sea." I have said nothing of law. This is an opinion, and I am inclined to defend it.

To show that the subject which I treated of was large hail, I would ask the Fellows to observe that in a large number of cases of hailstorms described the measurements of hailstones are given. In going through these accounts, I find that in 58 out of a total of 61 hailstorms noted in the first chapter, there is clear testimony to the hail being of very large size, such as nuts, walnuts, eggs, apples, oranges, and up to 12 inches in circumference. On the other hand, the great majority of the data extracted from logs in this paper seem to be reports of small hail. When one observer gives 116 records of hail while running about two-thirds round the southern hemisphere, we can hardly suppose that anything but either small hail or sleet is referred to, else the deck would have been cleared of its crew. The hail at Kerguelen on 24 days out of 70 fell in May and June, the beginning of winter or end of autumn. For my part I should never think of doubting that small hail may be very common in mid-ocean, both in the northern and southern temperate zone. I have myself experienced dense hailstorms in the extreme north of Scotland in September, but have not mentioned this in my book.

Further on, Mr. Harries adds to his previous misquotation by attributing to me the theory that hail at sea "is almost unknown," where "almost unknown" should be "uncommon," and "at sea" should be "in mid-ocean." His contention, however, is perfectly clear, and no doubt at variance with the belief expressed in my book, for he says that "great hailstorms are often met with on the open ocean." He then gives a number of examples of great hailstorms

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during a period from 1857 to 1891. Twelve of the twenty-two mentioned were great hailstorms within my meaning of the term. But were these twelve "in mid-ocean"? No. 1 (Capt. Jeffery) certainly was in mid-Atlantic. The only indication of the size of the hailstones is the word "immense." No. 2 (Capt. Peebles) occurred apparently about 300 or 400 miles from the African continent, which I should hardly describe as mid-ocean. I pass by the *Shun Lee* observation, for though it was in mid-Atlantic, the hailstones were only as big as large peas. No. 3 (Capt. Gray) was very near Cape Horn, and No. 4 (Capt. Gray) apparently within about 200 miles of land. No. 5, in 42° S. 60° W., was about the same distance from land. No. 6 (Capt. McRitchie) was apparently about 200 miles from land. No. 6A (Capt. McRitchie) was a good instance, say 1,000 miles from land. No. 7 (Capt. Gales) was close to Cape Horn, and the same remark applies to the next observation made by his brother near the same position, an interesting note of "large snowballs" in October. No. 8 (Capt. Kerr) was apparently 100 or 200 miles from the Cape of Good Hope, a fall of pieces of ice of great size, about 2 inches square, accompanying a waterspout and a terrible flash of lightning. No. 9 (Capt. Wight) was in a similar position. No. 10 (Capt. Wilson) was in mid-ocean, but the splinters of ice were only half-an-inch in length. No. 11, in the Bay of Biscay, was apparently about 150 miles from the coast of Brittany. The distances from land above given are merely from rough measurements on a chart, but I hope not very far wrong. The only other hailstorms of a severe character, as regards the size of hailstones, mentioned in the remainder of Mr. Harries' paper, are one observed by Capt. W. C. Smith, close to the coast of Natal, and one by Capt. Carruthers, about 400 miles from the South American coast. In this case the hail is described as of an "extraordinary size," but the largest seems to have measured no more than "half-an-inch square."

Thus we have finally a record in this paper of 14 hailstorms at sea, which by the test I have mentioned might be described as great. Of these, only four seem to have been more than about 300 miles from land, and only three more than about 400 miles from land. These three are Capt. Jeffery's of March 14th, 1883, in 41° N. 48° W.; Capt. Wilson's (pieces of ice like splinters ¼ in. in length), in 41° S. 49° E.; and Capt. McRitchie's ("hailstones as large as marbles"), in 38° S. 2° E. Thus no record remains of hailstones in mid-ocean, or more than 500 miles from a continent, in which the hailstones were more than ¼ in. long. And I have seen no account of great hailstones of such a size on any of the small non-mountainous islands lying in the vast central areas of the ocean. On the other hand, in the 61 instances I have given of storms on land, the *average* size of the hailstones would be about 1¼ in. in diameter; many were over 2, and some over 3 ins.

The influence of a continent is certainly considerable within 500 miles distance on the ocean: firstly, by reason of the masses of heated or cooled air which may be transported so far in a single day; and secondly, perhaps principally, in relation to hail, by reason of their deflecting great ocean-currents so as to bring warm and cold waters alongside each other. Southernmost Africa has the effect of bringing the equatorial and polar currents into proximity within a few hundred miles south of the land, and it is not surprising that the resulting differences of neighbouring air masses should give rise to storms. Similarly, the dense fogs off the coast of Newfoundland and a long way out to sea are produced by the deflection of an Arctic current so as to flow along the borders of the warm current from the south.

Mr. Harries has proved in this paper that hail has often been encountered at sea, and especially that certain large areas, such as the tract of ocean south and south-east of the Cape of Good Hope, are subject to great hailstorms, and I fully admit that he has shown these to be more prevalent than I had supposed, and acknowledge the value of this interesting contribution.

Capt. M. W. C. HEPWORTH said:—Being one of those who for years have been keeping some of those "gems," as Mr. Russell has satirically termed them, I wish to say that we who have been keeping these Meteorological Logs have been under the impression that we were materially aiding in the good cause. The wind and current charts I would remind Mr. Russell were drafted from logs kept by seamen. Hail is by no means an uncommon occurrence at sea, and even in the tropics I have seen it more than once.

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During a thunderstorm in the Red Sea, when the Telegraph Steamer *Hibernia* was laying the duplicate Bombay Cable in 1876, hail fell. In a private abstract log of mine observations of weather are recorded daily for noon at sea for many past years.

Rain, hail and snow occur less frequently at sea at about noon than at any other period during the 24 hours, so that although my records do not support Mr. Harries' contention as regards the frequency of hail at sea, the position in which they were recorded may be considered, and as bearing upon the subject.

By referring to my abstract I find that in 1,526 days at sea hail was recorded at noon 21 times. My abstract is of voyages made to many parts of the world; but I should mention that 18 passages were to Australia *viâ* the Cape of Good Hope, and that 12 of the return passages were made *viâ* the Suez Canal, and one *viâ* Cape Horn. Other voyages were to India, China, Japan, the Straits Settlements, America, and other parts.

Out of 21 h's that I find recorded at noon, 14 are in the South Indian Ocean between Cape Point and 46° S., three in the South Pacific Ocean, between New Zealand and 57° S.—on the only passage home made that way,—and four in the North Atlantic between Ushant and 40° N. The 17 cases of hail at noon recorded in the Southern Oceans occurred either in the trough, or immediately in rear of the trough of systems of low pressure.

Hail-squalls are common enough on the North Atlantic on the "Ash Tracks"—if I may use a sailor's expression—between England and America. I can vouch for that.

Mr. H. HARRIES, in reply, said that in quoting from page 154 of *On Hail*, he had inadvertently taken "almost unknown" from one line instead of "uncommon" in the next. The correction, however, introduces no difficulty, for it is now shown that hail is one of the most common of the phenomena recorded in many parts of the open ocean. With regard to Mr. Russell's view that we should take the expression "mid-ocean" in its narrowest sense, it is sufficient to say that ships usually follow certain well-known tracks, and it is only by chance that the centre of any particular ocean is visited: see page 8 of the *Report of the Meteorological Council* for the year ending March 31st, 1889, where it is stated that "the anticyclonic regions of the great oceans, . . . characterised by calms and light winds, are practically avoided by navigators." Then as to the suggestion that great hailstorms should be considered as storms in which the hailstones are very large, he (Mr. Harries) doubted very much whether anyone would support that view. Many English and Continental hailstorms are very severe and very destructive, and yet the stones are of the most ordinary size. The violent storm which burst over Vienna and other parts of Austria a year ago does not appear to have been remarkable for the size of the stones which fell, but it certainly was a very great hailstorm for all that, the gauges registering from 1 in. to 1¾ in. of water in little more than half-an-hour. The 2 ins. of hail in a few minutes noted by Capt. Gray, and the 3 ins. in 20 minutes by Capt. Holdich, nearly 1,200 miles from the Brazilian and New Zealand coasts respectively, would have been considered perfect avalanches had they occurred anywhere on land. There is no necessity to enter into details as to ships and dates, but the logs show that tremendous falls of hail, large hail noted in many cases, occur in the North Atlantic between 25° and 40° W., in the South Atlantic between 10° and 30° W., in the Indian Ocean between 50° and 100° E., in the South Pacific between 90° and 160° W., and in the North Pacific about the longitude of 180°, in positions which are from 1,000 to 2,000 miles from the nearest Continental land. Reference is made in the paper to a ship recording hail 96 times in crossing the Indian Ocean. The log shows the heaviest fall, the entry being underlined three times, to have been during violent squalls in 48° S. 52° E., or about 1,800 miles from the African coast. What would appear, from the similarity of the records, to have been a hail-storm of immense area was experienced by two vessels during a heavy Westerly gale in mid-ocean in July 1877. The ship *Taranaki* had excessively violent squalls of hail and rain at 4 p.m. on the 1st in 41½° S. 56½° E., and out of 21 weather entries down to midnight of the 4th, in 40½° S. 77° E., a run of 950 miles, hail was registered 14 times. The ship *Pomona* ran into the heavy hail squalls at 4 a.m. on the 2nd, in 46¾° S. 71° E., and out of 24 weather entries down to midnight of the 5th, in 47¾° S. 96½° E., a run of 1 000 miles, hail

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was registered 15 times. The heaviest part of this hailstorm was at about 2,000 miles from the African and Australian coasts respectively. It will be seen that the points at which the vessels first encountered the hail were 700 miles apart, and the points at which the hail ceased 900 miles apart. It might be of interest to note that while on land the tendency is for hailstorms to occur in the afternoon or evening, the evidence in the logs shows that at sea, where the daily range of temperature is comparatively very small, they seem to be fairly distributed over the 24 hours, often with and often without thunder and lightning. We sometimes read of rain from a cloudless sky; but in the course of this inquiry he (Mr. Harries) had only noticed one instance of hail under similar conditions. In September 1888, in 51½° S. 68½° W., the barque *Caldbeck* had a succession of heavy hail squalls for about eight hours, the cloud-form being "cum," amount 2, weather "b h," three entries of each, the observer remarking that the "cum" was on the horizon, the sky aloft being clear. Capt. Hepworth has mentioned a fall of hail in the Red Sea, but the log of the ss. *Hibernia* for November 16th, 1876, while it describes a severe thunderstorm with vivid forked lightning and very heavy rain between 9.30 and 10.30 a.m. in 21° N. 38° E., does not make any mention of hail. There was, however, a sharp drop in the shade temperature—8 a.m. 88°·5; noon, 83°·2; 4 p.m. 86°·5.

Capt. D. WILSON-BARKER wrote that he had not been struck by any apparent difference between the amount or frequency of hail at sea and on land. He sent the following extract from a letter he had received from Capt. D. Morton, of the Telegraph Ship *Dacia*, June 14th, 1895:—"On February 5th last, while repairing the Spanish National Cable, we had to seek shelter in the Port of Mazighan,[1] in lat. 38°15′·6″ N. long. 8°26′·6″ W. On the morning of the 6th, about 10.30 a.m., we experienced a heavy fall of hail, which lasted for about 10 minutes, the hailstones being the largest I have ever seen, being about the size of marbles. The barometer on board at this time stood at 29·515 ins., dry-bulb 57°·5, wet-bulb 57°, wind fresh from West. The fact that such a thing was unknown in this port at any former time may make it interesting."

Admiral J. P. MACLEAR, who was unable to remain for the discussion, wrote that he had examined the *Challenger* observations during her 8½ years' cruise, and found six entries of hail, viz. January 27th, 1873, 60 miles west of Gibraltar: 3 p.m., hail squall from West-north-west; May 15th, 1873, at Halifax: "h" recorded one hour; January 5th, 1874, lat. 48° S., long. 62° E.: 10 p.m., heavy hail squall, during which wind shifted to South-south-east; January 22nd, 1874, at Kerguelen island: 1.30 a.m., a sharp hail shower; January 25th, 1876, at Port Stanley, Falklands: "h" recorded one hour; February 10th, 1876, lat. 44° S., long. 56° W.: 0.30 a.m., a hail squall, 7.30 p.m., heavy squall with hail.

Coast of Morocco.

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PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

May 15th, 1895.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

Lt.-Col. HARLOVEN MORLEY SAUNDERS, Oakfield, The Park, Cheltenham, was balloted for and duly elected a Fellow of the Society.

The following communications were read:—

"THE NOVEMBER FLOODS OF 1894 IN THE THAMES VALLEY." By G. J. SYMONS, F.R.S., and G. CHATTERTON, M.A., M.Inst.C.E. (p. 189.)

"BAROMETRICAL CHANGES PRECEDING AND ACCOMPANYING THE HEAVY RAINFALL OF NOVEMBER, 1894." By F. J. BRODIE, F.R.Met.Soc. (p. 209.)

"A NATURAL THERMOMETER." By Rev. FENWICK W. STOW, M.A., F.R.Met.Soc. (p. 214.)

June 19th, 1895.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

STRATTON COLLINGS KNOTT, H.B.M. Vice-Consul, Mojanga, Madagascar; and ROLAND PILLINGS, F.R.A.S., Secretary, Meteorological Commission, Cape Town, were balloted for and duly elected Fellows of the Society.

The following communications were read:—

"HOURLY VARIATION OF SUNSHINE AT SEVEN STATIONS IN THE BRITISH ISLES." By RICHARD H. CURTIS, F.R.Met.Soc. (p. 216.)

"THE FREQUENCY, SIZE, AND DISTRIBUTION OF HAIL AT SEA." By HENRY HARRIES, F.R.Met.Soc. (p. 230.)

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CORRESPONDENCE AND NOTES.

Weather Bureau, Washington.—Prof. Mark W. Harrington has retired from the post of Chief of the U.S. Weather Bureau, and Prof. Willis L. Moore has been appointed as his successor.

Prof. Moore entered the Signal Service School at Fort Myer in 1876, and ranked second in a graduating class of thirty members. In 1886 he was made a Sergeant on account of his having devised certain improved methods of issuing the daily weather forecasts and maps. After being stationed at Chicago, Ill., and Albany, N.Y., Prof. Moore was transferred to the Central Office in Washington, where he remained till 1891. In that year he was transferred to Minneapolis, Minn., and later to Milwaukee, Wis., at which places he was Local Forecast Official and Director of the State Weather Services. During the past year Prof. Moore entered the competitive examination for a professorship in the Weather Bureau, and attained the highest rank among the ten candidates who had stood best in the examination, and were therefore selected to compete in practical forecasting. His attainment of this rank gave him the professorship. Since his appointment as professor, the present Chief of the Weather Bureau has been Local Forecast Official at Chicago, Ill., where during the past winter he made a very fine record in his cold wave forecasts.—*American Meteorological Journal.*

The Sonnblick Observatory.—A general meeting of the Sonnblick Verein was held on April 6th. The President, Colonel Edler von Obermayer, was able to report an increase in the number of members, but urged the necessity of obtaining still wider support in the future. A paper on the scientific results of the Sonnblick observations up to the present time was read by Dr. W. Trabert. First must be placed the startling result reached by Hann, chiefly from a discussion of the Sonnblick observations, that the central column of air in a cyclonic system does not ascend by reason of relatively higher temperature, being in fact, colder than the air surrounding it; nor does the air in the descending current of an anti-cyclone attain its greater relative density by reason of lower temperature. This conclusion produced almost a revolution in the domain of dynamical meteorology, as it was practically a death-blow to what was known as the convectional theory of cyclones. Dr. Trabert gave an account of some researches made by himself on the warming of the air by direct absorption of the sun's heat at a mountain summit. The results which have already been published in full, show that, as at lower levels, the air is chiefly warmed by convection from the earth's surface. Hann has further succeeded in estimating the daily range of temperature in the free air not affected by ascending and descending currents from mountains—an investigation which was always supposed to involve observations from balloons. In a zone such as that between the summits of the Sonnblick and Mont Blanc, the daily range was found to amount to only 1°C. Hann further points out than the Sonnblick observations agree with those of other mountain stations in throwing considerable doubt on modern theories explaining variations of wind velocity. Investigations more in the domain of pure physics have been made by Elster and Geitel, on the nature of St. Elmo's fire, the atmospheric absorption of the ultra-violet rays, etc. Trabert and Pernter are at present engaged in an extensive work dealing with the general geographical relations of the results just enumerated.—*The Geographical Journal.*

A High-Level Observatory in Tasmania.—In May last Mr. Clement L. Wragge induced the Government of Tasmania to establish a meteorological observatory on Mount Wellington, four miles in a straight line from Hobart. At the Springs, 2,495 feet above sea-level, Constable Gadd's quarters were fixed on as a half-way observatory, and thermometers and a barometer will shortly be placed there. Later on a barograph, thermograph, and hydrograph will be set

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up at the Springs. When the party arrived at the summit, 4,166 feet above sea-level, a cairn already commenced to protect the instruments on a pile of jagged rock, 150 yards west of the pinnacle, was completed. Here the instruments were placed, most of them self-registering, and of the latest and most approved types, an enlarged Stevenson screen being used for the thermometers, as at Hobart and the Springs. In the meantime they will be read once a week, but a permanent observatory is in course of erection, and, when it is finished, observations will be recorded daily. The thermometer on the summit marked 42° at 3 p.m. Mr. Wragge was assisted in carrying up the instruments by Mr. Kingsmill, of the Hobart Observatory, and by Captain Balfour, of the *Penguin*, who placed six sailors at his disposal.—*Scottish Geographical Magazine.*

Fogs in the North Atlantic.—In the *Pilot Chart* for July the U.S. Hydrographic Office gives twelve monthly charts, which represent graphically the regions where fog was experienced most frequently on the North Atlantic during 1894, as shown by reports from the voluntary observers of the Hydrographic Office. This year can be taken as a typical one to illustrate the fog areas at the different seasons. During January, February, and March, fog is experienced on the Great Banks, and to the westward, but not in large quantities. During April it begins to extend to the northward and eastward, increasing in frequency as the spring advances, and reaching its maximum generally in June or July, during which months it may be expected anywhere between the American coast and the British Isles in large areas and of long duration. In August the fog begins to dissipate in the eastern part of the ocean, and in September the decrease is very perceptible. During the remaining three months it falls to the minimum again.

RECENT PUBLICATIONS.

American Meteorological Journal. June-August 1895. 8vo.

The principal articles are :—The Thermophone: by H. E. Warren and G. C. Whipple (16 pp.). This is a description of a new instrument for obtaining the temperature of a distant or inaccessible place. The authors also give an account of some observations which have been made with the instrument, on the temperature of surface waters.—California electrical storms: by J. D. Parker (5 pp.).—The Augusta, Ga.. tornado of March 20th, 1895: by W. J. Wambaugh (6 pp.).—Psychic effects of the weather: by C. A. Beals (7 pp.).—The geographical distribution of the maximum and minimum hourly wind velocities, and their relations to the average daily wind velocities for January and July, for the United States: by Dr. F. Waldo (15 pp.).—Relation of clouds to rainfall: by H. H. Clayton (7 pp.). During 1887 and 1888 hourly cloud observations were taken at the Blue Hill Observatory, with but few omissions, for 16 hours of each day between 7 a.m. and 11 p.m. From an analysis of these observations the author is of opinion that cloud forms cannot in general be used in predicting rain for an interval exceeding 24 hours, but for a few hours in advance the existence of certain cloud forms frequently furnish the individual observer more reliable indications of the coming rain than does the weather map. If the detailed cloud forms, the pressure, wind, cloud movements, humidity, &c., were considered, the forecasting value of the clouds would no doubt be considerably increased.—The meteorograph for the Harvard Observatory on El Misti, Peru: by S. P. Fergusson (4 pp.). As it is impossible to maintain observers on the summit of El Misti, which is 19,300 feet above sea-level, this special self-recording instrument has been devised for use on the mountain. The clock is intended to run for four months without re-winding, and one year's supply of paper can be placed upon the rolls at one time.—Electrical phenomena in a dust storm: by F. P. Gulliver (5 pp.).

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Annuaire de la Société Météorologique de France. December 1894-January 1895. 4to.

Contains:—Distribution annuelle des orages à la surface du globe terrestre: par A. Klossovsky (4 pp.).—Sur l'aurore boréale du 13 novembre 1894: par A. Angot (2 pp.).—Notes sur la photographie des Nuages: par A. Angot (5 pp.).—De la durée de le pluie en heures au Parc Saint Maur et à Perpignan: par P. Cœurdevache (4 pp.).—Variation diurne de la fréquence de la pluie: par P. Cœurdevache (2 pp.).—Eclairs du 19 décembre 1894: par M. Tardy (2 pp.).—Les orages à Montdidier (Somme), d'après les Drs. Chandon: par V. Raulin (8 pp.).—Sur la diminution progressive des pluies dans le Calvados: par G. Guilbert (3 pp.).

British Rainfall, 1894. Compiled by G. J. SYMONS, F.R.S., and H. SOWERBY WALLIS. 8vo. 1895.

This work increases in value year by year. It was started in 1860 with records from 168 stations. The present volume for 1894 contains records from 3,043 stations. Notwithstanding this large increase, more stations are required in Scotland, and especially in Ireland.

The total rainfall over the British Isles for 1894 was about 6 per cent. above the average. The greatest rainfall was 166·22 ins. at The Stye, Cumberland, and the least 18·56 ins. at Leicester. The heaviest fall in one day was 7·74 ins. at Ben Nevis Observatory on February 6th.

In addition to the usual information on the rainfall for the year, the volume contains articles upon various branches of rainfall work, among which may be mentioned "The Dryness of years ending with 4," and "The October and November Floods."

Journal and Proceedings of the Royal Society of New South Wales. Vol. XXVIII. 1894. 8vo.

Contains the following articles on meteorological subjects:—An Essay on Southerly Bursters: by H. A. Hunt (48 pp.).—Current Papers: by H. C. Russell, F.R.S. (12 pp.).—A Map, showing the average Monthly Rainfall in New South Wales: by H. C. Russell, F.R.S. (3 pp.).—On a new Velocity Recorder and its application to Anemometry and other purposes: by J. A. Griffiths (9 pp.).

Meteorologische Zeitschrift. Redigirt von Dr. J. HANN und Dr. G. HELLMANN. May and June 1895. 4to.

The principal articles are:—Wolkenbildung durch das Nordlicht: von Dr. A. Paulsen (9 pp.). The author cites numerous utterences of older writers like Bravais and Weyprecht on the analogies between auroras and certain cloud forms. It is well known to most observers that cirrus cloud occasionally appears just like the rays of an aurora, and Dr. Paulsen quotes reports from Dr. Hildebrandsson of luminous clouds which appear and disappear suddenly: and he endeavours to prove that all the clouds which resemble auroras are really only ordinary clouds of water or ice dust, which owe their existence to the auroral discharge, and are illuminated by it. It is a known fact that the discharge from a cathode, when absorbed in the atmosphere, generates ozone freely, and this condenses aqueous vapour. If we imagine an aurora immoveable, it would envelope itself in a cloud, and accordingly Weyprecht's statement that auroras which are indistinct have no action on the magnetic needle appears well founded. The aurora, according to Dr. Paulsen, is closely similar to the cathode discharge.—Ueber die Ermittlung der Temperatur und Feuchtigkeits-Unterschiede zwischen Wald und Feld: von E. Ebermayer (6 pp.). This is an interesting account of observations carried out by means of Assmann's aspirator at Eberswalde. These show very much lower differences between the forest and the clearances than resulted from the ordinary thermometer screen. But Dr. Ebermayer goes on to show that this result is mainly due to the type of screen in use in North Germany, and that the results obtained from the mode of exposure in Bavaria agree very closely with those obtained by the aspirating apparatus.—Der Föhn vom 13 Januar 1895 am Nordfuss der Alpen und die Bildung einer Theildepres-

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sion daselbst: von R. Billwiller (9 pp.). This is an interesting account of the appearance of the föhn in Switzerland in the middle of January. Dr. Billwiller describes the conditions prevailing over Central Europe during the frost of the first part of January, and shows how the appearance of a depression off the West of Ireland gradually made its influence felt as far as Switzerland, and drew the air over the Alps. The föhn appeared first at the lowest pass of the St. Gothard, and subsequently at others, following according to their altitude. According to the author, the föhn distinctly gave rise to a secondary depression over Switzerland, whereas M. Hébert, in his paper on the föhn and sirocco, states that the local depression produced the föhn.

Sitzungsberichte der kaiserlichen Akademie der Wissenschaften in Wien. Band CIV. Abth. II. April 1895. 8vo.

Contains a paper by Dr. Hann, "Die Verhältnisse der Luftfeuchtigkeit auf dem Sonnblickgipfel" (51 pp.). This is an analysis of the records of a Richard hydrograph, which has been in use at the observatory on the Sonnblick since September 1893, so that two full winters have been available for the discussion. Dr. Hann expresses himself as thoroughly satisfied with the performance of the Richard instrument, having compared it carefully with Koppe's hair hygrometer, and with the dry and wet bulb psychrometer. He points out that as a rule at mountain stations the annual course of relative humidity is the opposite to that which prevails at low level stations, for the minimum falls in winter and the maximum in summer. The author gives tables of the diurnal range of the relative humidity in the different months and its relation to sunshine, and to clear and cloudy days respectively, and concludes the paper with a discussion of the phenomena observed during periods of great dryness.

Symons's Monthly Meteorological Magazine. June-September 1895. 8vo.

The principal articles are:—Rainfall Observations in China, 1886-92: by M. le Prof. Raulin (3 pp.). The author has summarised the observations collected and published by Dr. Doberck, of the Hongkong Observatory. The mean annual rainfall is small in the North, and increases greatly towards the South. From about 20 inches in the Gulf of Pe-chi-li it becomes double that in the Delta of the Yang-Tse-Kaing, and going about 500 miles up the river it is 58 inches at Hankow. Continuing along the coast it is about 45 inches, but reaches 68 inches at Ningpo. At Canton it is 66 inches, in the north of the island of Hainan 54 inches, in Formosa it ranges from 60 to 90 inches; but at Keelung the north-east point it reaches 148 inches.—Earth Temperature and Water Pipes (2 pp.).—The Dryness of the first half of 1895 (3 pp.). It appears that the greatest deficiency of rainfall was slightly to the north-east of London.—Indelible Degree Marks on Thermometers (2 pp.). This describes an invention recently brought out by Mr. J. J. Hicks for securing an imperishable scale for thermometers.—The Rainfall of Belgium (4 pp.).—Aqueous Vapour and Temperature: by J. R. Sutton (3 pp.).—The Yorkshire Whirlwind of August 10th (5 pp.).—Temperature of European Rivers: by H. N. Dickson (2 pp.).

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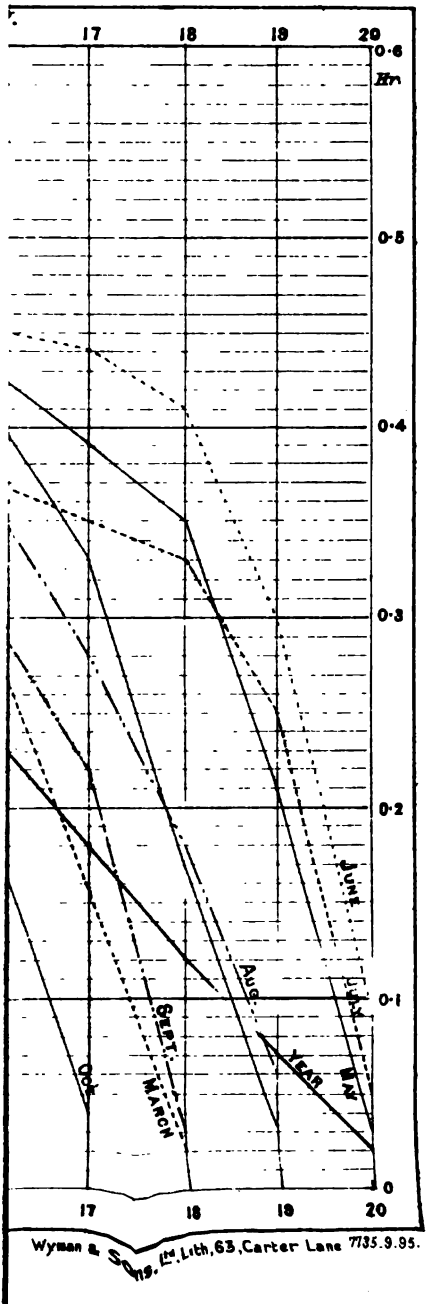

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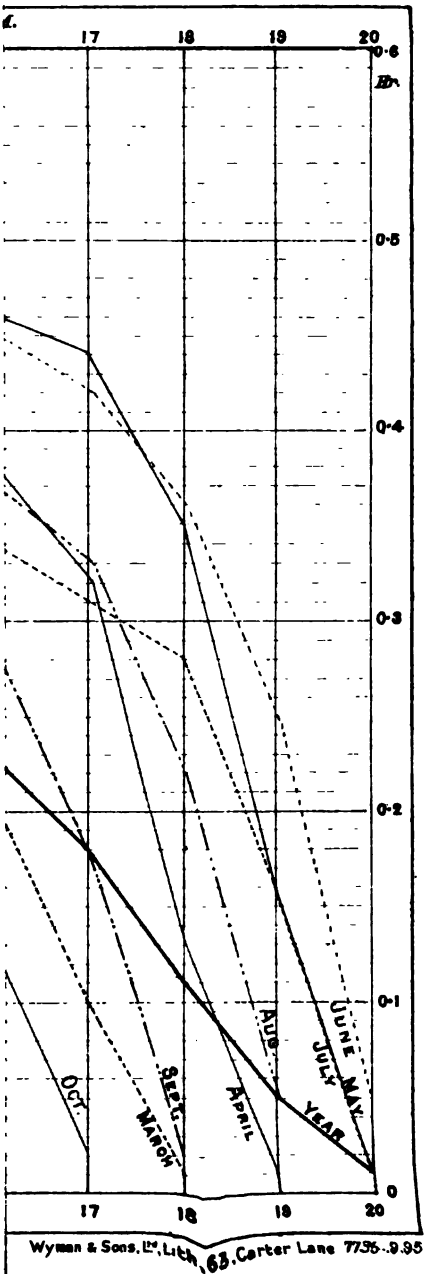

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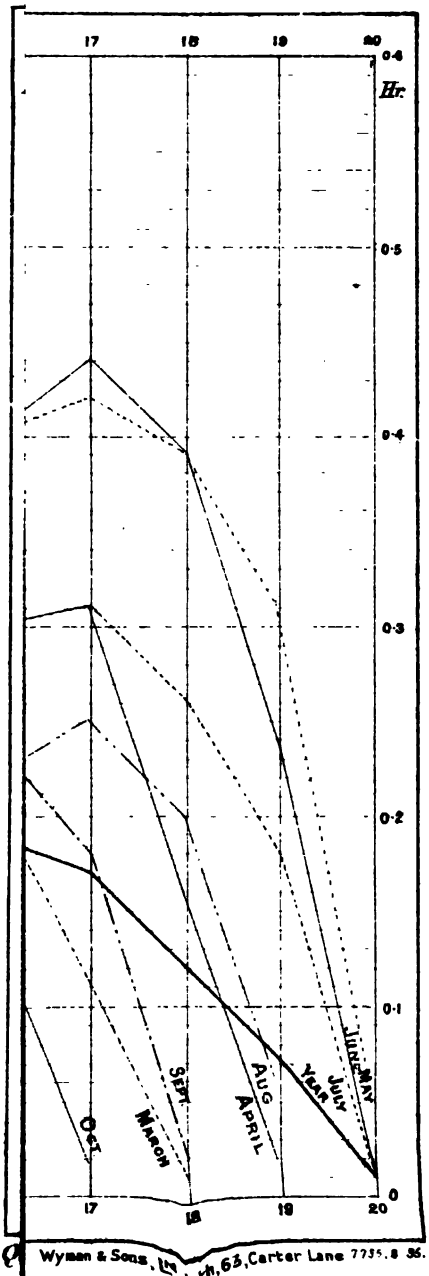

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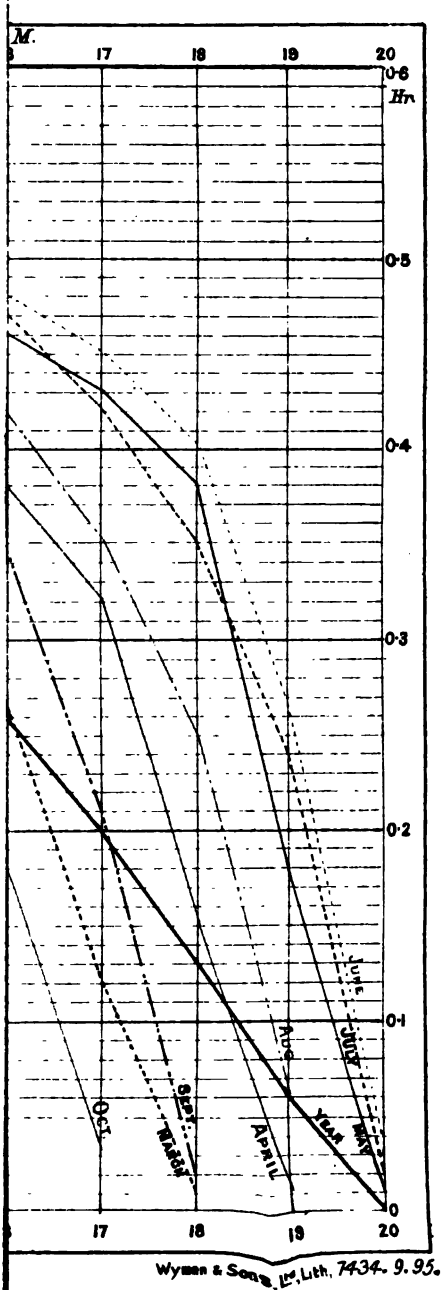

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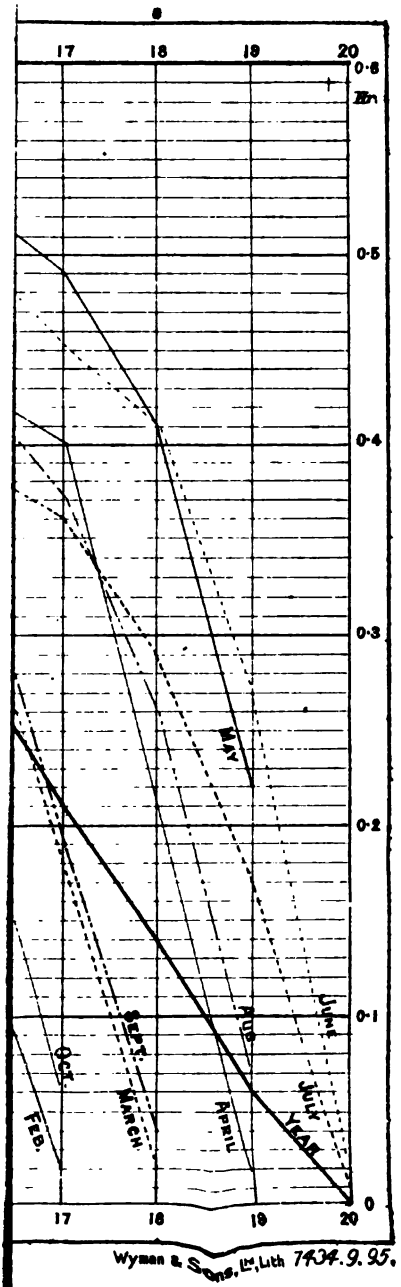

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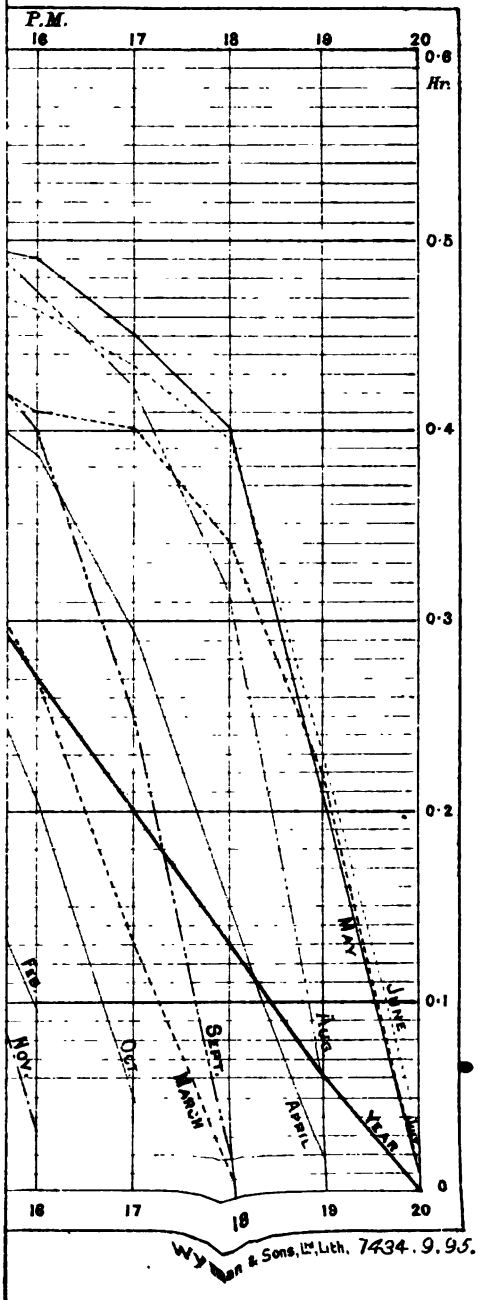

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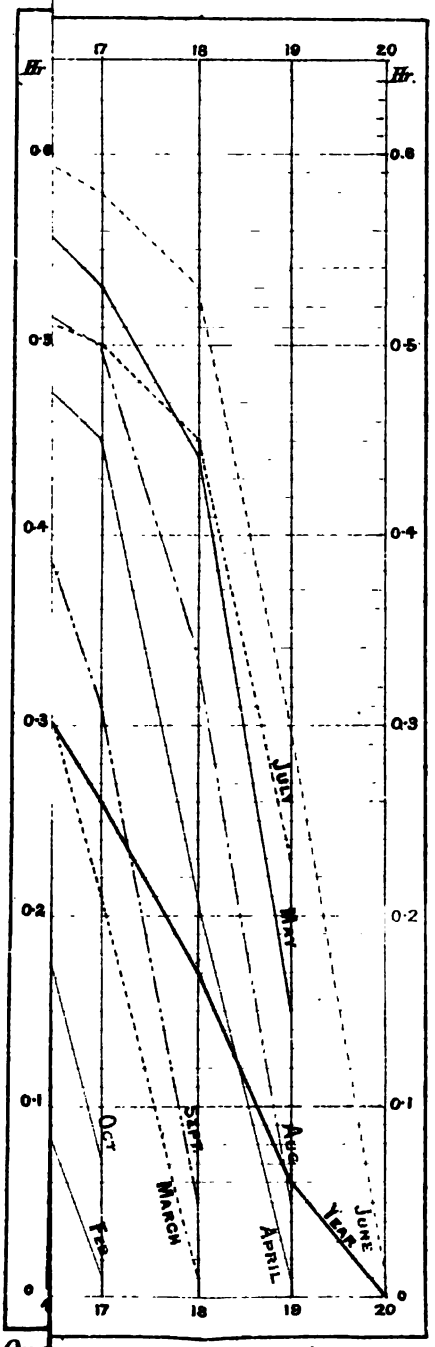

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